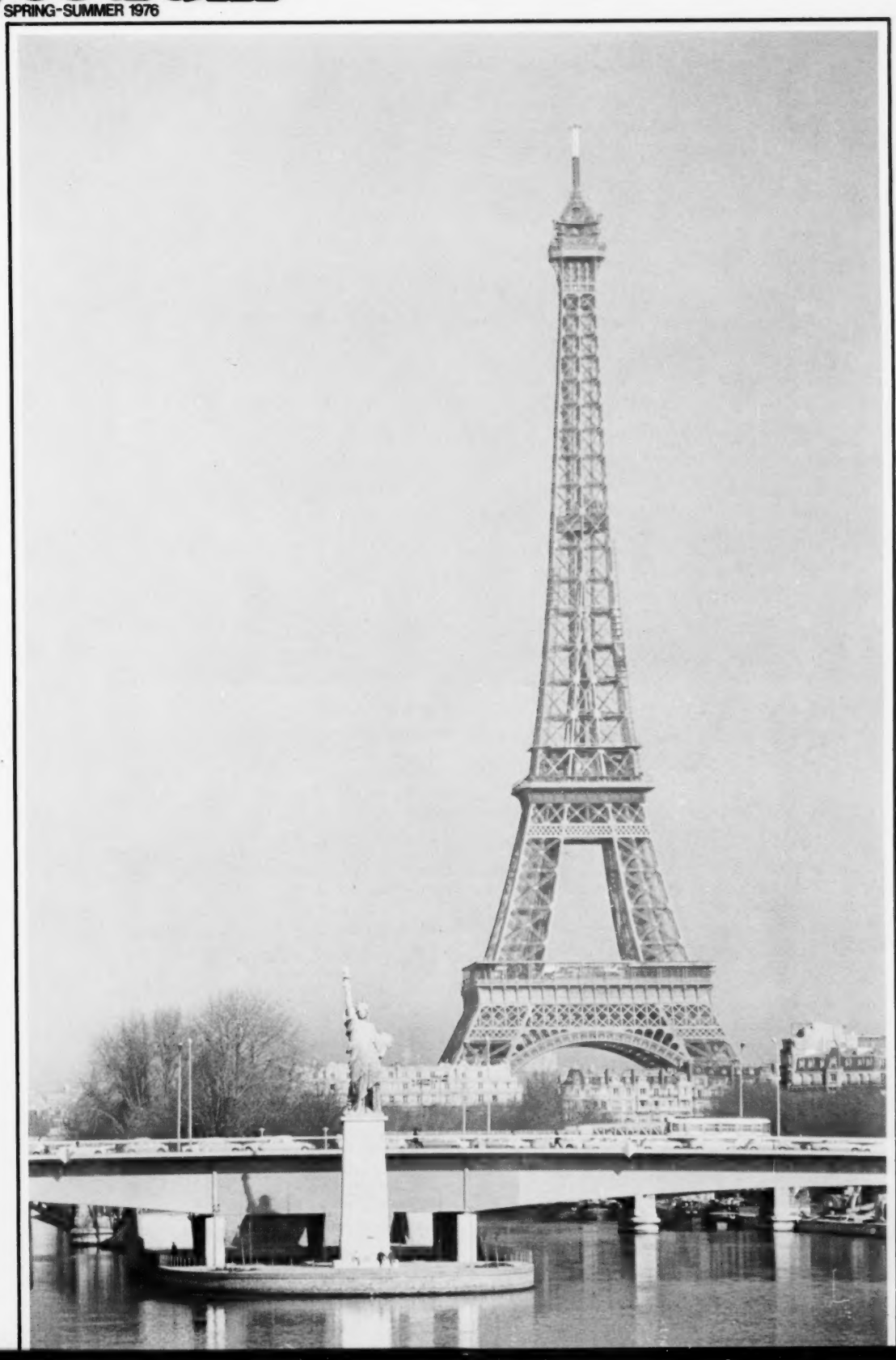
Water spectrum

SPRING-SUMMER 1976



Water Spectrum

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COVER: Familiar Eiffel Tower in background dwarfs this 30-foot Parisian miniature of original Statue of Liberty. The Seine in foreground has been receiving equal attention from French citizens. *See page 29.*

French Government Tourist Office

A Year Later... Mr. Veysey Looks Ahead

The Honorable Victor V. Veysey is the first person to be appointed to the new office of Assistant Secretary of the Army for Civil Works. Having recently completed his first year in office, the Assistant Secretary was interviewed by the editor of Water Spectrum *to determine his impressions of the new job.*

Mr. Secretary, what is your job?

I am the Assistant Secretary of the Army for Civil Works, which is a new function that the Congress authorized several years ago. Heretofore, policy guidance for the Civil Works program of the Army Corps of Engineers had come from the Secretary of the Army, who was and is a very busy man, and who probably didn't have the opportunity to spend as much time with the Corps component of the Army as he would have liked. I try to give policy direction to the Corps to enhance its effectiveness in improving the quality of life through water resources development.

The past year has confirmed my earlier feelings regarding the competence and integrity of the Corps of Engineers in handling engineering and construction projects.

Would you consider the Corps the Nation's construction agency?

It is and has been for over 200 years. The Corps of Engineers has been called upon to do a lot of different types of assignments. Although its directions have been changed often by the actions of the Congress and the Executive Branch in that 200 year period, the Corps has always had the capability, flexibility and versatility to respond to each new direction. That resiliency, that capacity to adapt to new problems, is reflected today in the changing emphasis the Corps is placing on its current programs.

How would you assess the changing priorities in developing and managing water resources?

Through the budget cycle we have placed our resources, in terms of dollars and manpower, on the highest priority matters. At this particular time in our Nation's history, we are facing the very acute problem of an energy shortage and that has caused us to place top priority on the use of water for energy. We've escalated that authorization into the development of hydroelectric power capability, both at existing sites—which we have already partially developed—and at new sites that have been under study or construction for some time. Additional new sites are still in the planning stages, and we are looking at new techniques and equipment for developing more power from water running downhill.

There are other uses of water in the energy cycle that are important, or are going to be quite important. In addition to cooling, there is the use of water for the development of our coal and oil shale resources. This will require a very large supply of water.

Water quality—or perhaps I should say the protection of the quality of our water resources—has equal priority for the Corps.

Additionally, I would mention water navigation as an area of emphasis for the Corps. This has always been one of the Corps' principal national objectives. It is even more so today as we find our transportation system under considerable pressure and stress to deliver the type of service that we would like.

Furthermore, water navigation is well established as the least energy consuming method of moving goods, being, on the average, 25 or 30 percent more energy efficient than alternate modes.

Yet another area of priority is the assignment given to the Corps in the 1930s and 1940s with respect to flood protection. The Corps has investigated, planned and constructed flood control measures. At the same time, as the nation has grown, we have increased our exposure to flood hazards, in regard to both life and property. We have not yet fully mastered the techniques which will reduce the amount of our annual losses to floods.

You once stated that, although you feel the U.S. Army Corps of Engineers leads all other Federal agencies in complying with environmental legislation, more needs to be done. What are your thoughts on today's environmental goals and objectives?

It is an unchallenged fact that the Corps of Engineers, ever since 1970, the effective date of the NEPA[1] legislation, has been in the forefront of developing and implementing the procedures called for in that significant legislation. Although we have prepared many hundreds of excellent environmental impact statements covering each ongoing project or operation, there is another aspect, and that is carrying out an active role in terms of protecting and enhancing the environment. I think this is the significant new area in which the versatility and competence of the Corps are being put to use by the Congress.

We have some responsibilities of this nature through our several permit authorities, which may give us the opportunity to protect some of our water resources. We also have some affirmative action opportunities of doing things that are environmentally attractive while carrying out our basic mission, whether it be navigation, flood protection or water supply. I hope that this will reverse the old image of the Corps from that of being totally developmentally oriented to one of being equally environmentally oriented. The environmental quality objective is going to be incorporated into all of our planning from the very first day forward rather than added as an afterthought.

Lastly, the Corps is seeking the best efforts of all of its employees to place new emphasis on meeting this challenge. All employees of the Corps will be striving to increase their individual sensitivity to environmental needs and to enable the Corps, as an institution, to respond to the environmental concerns of our Nation.

You mentioned NEPA. What do you think has been its greatest impact?

NEPA's greatest impact has been to formally introduce environmental considerations into the decision-making processes and to require that the public be given an opportunity to participate with the decision makers as to what direction should be taken. This puts our planning in a fishbowl context, but it is very helpful in reaching consensus among the various publics that have differing points of view with respect to our projects.

It is in this area that the most striking steps forward have been taken by the Corps in terms of developing a very sophisticated way of bringing the public into a participatory role through public hearings and public meetings. These lay out the alternative solutions to a project, array the significant environmental impacts, and open them for discussion by the public.

"We have not yet fully mastered the techniques which will reduce . . . our annual losses to floods."

One area of public environmental concern is the disposal of dredged material. How much progress has been made in determining the nature of this material? Also, what is the possibility of putting it to some beneficial use?

Since environmental concerns have become important to the Corps, it has been spending substantial sums of money at its Waterways Experiment Station at Vicksburg, Mississippi looking into the problems of what to do with dredged material (which used to be called "dredged spoil"). We are looking upon it not as something that we have to discard, but as a useful material.

People's apprehensions were a little overblown. Most of the material that is dredged out of our waterways results from the natural processes that wash our soils into our rivers and harbors; it is nothing more than the soil that comes off our hillsides. It is in the wrong place of course, but it is not truly a pollutant; however, sometimes there are pollutants mixed with it that come from agricultural, industrial and municipal sources. Some of these have to be handled very carefully. We also have found that some of these wastes are, if not properly managed, damaging to our health and to the environment.

". . . reverse the old image of the Corps from . . . totally developmentally oriented to . . . equally environmentally oriented."

Now that we have more knowledge about the nature of these materials, real innovations are coming, with imaginative ways for using them constructively. The Corps had accidentally done some of this in the past when it found that some islands built out of dredged material adapted themselves into excellent wildlife refuges and habitats.

We realize it is now possible to deliberately build valuable wildlife enhancement resources out of dredged material. Productive wetlands need to be constructed to replace those wetland areas which have been diminishing rapidly due to development. In other situations, we can construct fast lands for recreation purposes, airports, industrial development or whatever else by using this material without adversely impacting on wetland values. After more research is done, we will have even better ways of carrying out some of these objectives in the future.

[1] *National Environmental Policy Act*

Your mention of wetlands brings up Section 404 of the 1972 Amendments to the Federal Water Pollution Control Act, which authorizes the Secretary of the Army, through the Corps of Engineers, to issue permits for the discharge of dredged or fill material in the waters of the United States, including wetlands. What has been happening with this permit program?

Section 404 is an extension of a trend that has been evolving over many years to use the Corps' capability to regulate construction in and around our waterways. That trend extends from our original roles of protecting the safety of our waterways to a new type of Federal interest—in terms of water quality—protection against pollution.

Section 404 has caused us to develop implementing regulations, which has been a most difficult exercise for the Corps and other related agencies. After these regulations were promulgated last summer the Corps undertook a most commendable approach in terms of widespread public hearings and public meetings all over the country. The result is a much better understanding of what the Corps of Engineers is called on to do, why it is doing it, and how it is going to implement these regulations. We do have a better informed public to work with than would have been the case a year ago.

"Most of the material . . . dredged out of our waterways results from the natural processes . . ."

I expect, as time goes on, we will again revise the regulations. We are seeing, also, reasons to recommend to the Congress certain changes in the basic law; for example, to provide a clearcut basis for calling on the States to take on the water quality protection role for tributaries and streams of a more local character. The Corps of Engineers can and should protect the truly navigable waters, but perhaps we can help the States develop their own capability to manage the smaller streams. Developments of that type will be taking place throughout the next year or two.

Section 404 also covers wetland areas, but how are we to classify them?

To many people this is a new concept meaning lands that are wet, more or less, and have specific types of plants growing on them. Not all wetlands are equal in value. Some wetlands are most important in maintaining our fish and wildlife food chains, in purifying polluted waters, and in providing a national water resource. It is these critical and highly productive areas that we are particularly concerned about and want to protect. Protecting all wetlands may not be the answer. A practical classification system for wetlands is required and we don't have that type of knowledge and understanding at the present time.

The Corps, other agencies and independent scientists are making efforts to quantify wetland values in terms, perhaps, of the dollars or energy units that they produce. I expect we will continue to press forward in finding ways to quantify the value of our wetlands so that we will know how much we should spend in protecting the truly valuable areas.

How can we use our technology to help?

We have a great deal of technology, although it is just developing in terms of understanding its significance. For example, the Nation has developed a lot of remote sensing capability—by that I mean the capability to measure, or photograph, or get data about our terrain from aircraft, from satellites or from any number of remote locations. After more study of this capability, I think we will be able to map the wetlands, to classify them, to be able to observe and evaluate changes that either improve or deteriorate these wetlands, and thus know a great deal more about the environmental consequences of our programs. Remote sensing may open the way for us to produce a real environmental inventory in specific areas of concern to the Corps, at least where projects are located, and eventually for the entire Nation.

"Remote sensing may open the way for us to produce a real environmental inventory . . ."

We are only beginning to tap the potential. I think remote sensing has an enormous potential, for example, for assisting us in our flood control activities. I imagine that this exciting new inflow of information is going to change our perspective. We may have thought or believed certain things to be true in the past and we may find out, when we look at the earth from the remoteness of a satellite, that maybe our concepts weren't right and that we are going to revise some things.

Speaking of changing our perspective, the 1974 Water Resources Development Act authorized the Corps to pursue nonstructural alternatives to prevent future flood damage. Do you anticipate extensive use of nonstructural solutions?

Yes, I do; but there are difficulties in the way. This opening of the door actually came from the initiative of the Corps. It was based on our experience and our general feeling that, while we build many standard flood control projects of reservoirs and channels, we still continue to have very heavy flood losses and we need to find even better ways to handle this problem. So, the nonstructural alternative was indicated as desirable. It also fits in with the environmental and recreational orientation of so many Americans today.

Our first projects with totally acceptable, nonstructural alternatives are just beginning to come along. Interestingly enough, some of these landmark projects actually can be accomplished with less total expenditure than the conventional type of flood control protection, and they are much more acceptable in many communities. However, there are a lot of institutional difficulties in implementing them. We don't really have good guidelines yet as to how nonstructural alternatives should look, and we are hung up by cost sharing provisions, which make it extremely difficult and maybe totally impractical in some situations for local communities to come up with the matching funds necessary to implement a highly desirable project.

Speaking of cost sharing, aren't we supposed to get some guidance through a new Principles and Standards doctrine, incorporating some environmental enhancement objectives?

Well, yes, we are. A so-called Section 80 study was completed this year. The Corps of Engineers put considerable resources into helping develop this study which was authorized by the Congress in the Water Resources Development Act of 1974. Congress directed the Water Resources Council to be responsible for the overall study. We did a great deal of work on it and took a leadership role in developing the material. It has led the way for some tentative recommendations by the Water Resources Council with respect to cost sharing and new Principles and Standards, but these have yet to be addressed by the Executive Branch and have to be returned to Congress before they are implemented. So we are really some distance away from the answers.

Clearly, there are a number of different philosophies that can be applied. One of them is that the role of the Federal government, or the amount of expenditure made by the Federal government, should be limited by requiring a higher percentage of cost sharing in every instance from local government. This inhibits the approach which says, "Well, it's free Federal money; let's get all we can," because then some other problems come up. Certain local jurisdictions have great financial capability to develop sharing funds, while others have virtually no capability, so there is an element of unfairness when you increase these levels of participation.

Secondly, some projects are truly Federal in nature. These are the massive projects that bring benefits to a widespread population and are located in more than one State—like major basin flood control projects or major navigation projects that carry traffic into wide areas. These are really Federal concerns and expecting a high level of local cost sharing is wrong. They should be undertaken by the Federal government as Federal projects just as small projects, local in their impacts and benefits, should be constructed purely by local interests.

With so many water-short areas in the United States, should we establish priorities to supply energy, agriculture and industrial demands?

We have moved, thus far, into the area of multiple use of water resources. Water that is used for navigation can also be used for hydroelectric power generation, municipal-industrial supplies, and fish and wildlife enhancement. Even so, it appears quite clear there isn't going to be a sufficient supply of water available.

We are going to have to do some additional things. We just have to get into reuse of water, kind of a recycling process, in which we can find better ways of using and reusing our water.

"We just have to get into reuse of water . . ."

The Corps and EPA have worked on a land-treatment approach which, to me, is really the wave of the future. Now we are building enormous treatment plants that require huge amounts of energy and chemicals, and then dumping the treated water back into our streams. This is just not the correct approach. There is a natural, biological cycle and we had better be heedful of it. Human and animal waste products become the nutrients for plants when they are returned to the soil for purification.

There has been talk about major water resource importation projects. Out West, for example, we might build projects linking huge water resources in Alaska and Canada with those in the United States and clear down into Mexico. We don't need those now, of course, but they wouldn't be built in a day either. I think we should direct some national attention and planning to bring these into development at the appropriate time in our national history.

I am intrigued also with another possibility which may not be within the role of the Corps; that is the use of weather management to increase the available amount of precipitation or water in a basin area. I think there is a lot of potential if we learn how to manage it right.

Mr. Secretary, are you suggesting that we can satisfy a good many of these future demands by combinations of multiple use of water, recycling of water through land treatment, importation and weather management?

Yes, we certainly can. If developed wisely, our water resource is enormous; wasted and undeveloped, it is too small for our needs. In this regard, the Corps should perform many of the major planning, engineering and construction functions for the Federal interest in water resource projects.

The Corps has a recreation program in which it tries to use water available for other purposes. Is this a proper direction?

The amount of utilization that the Corps is getting on its reservoirs, built for other purposes, is really startling. Annual visitations approaching the 400 million level are projecting us into an entirely new and rapidly growing role, that of managing these water resources for the maximum development of recreational opportunities. People will flock to a close-in reservoir that is within a short drive from their homes. We've been limited in this regard, because we're not historically a recreation group; however, managing reservoirs for multiple uses brings the Corps into contact with a lot of people whose intent is to enjoy the water for recreation. It is a great opportunity because we have a chance to talk with these people and also to talk a little bit about the Corps of Engineers and its role.

"One of our goals is to provide maximum utilization of a facility created for the public by a Federal investment."

How do you relate the concept of lakeshore management to the increasing public demands for more water-based recreation?

One of our goals is to provide maximum utilization of a facility created for the public by a Federal investment. Sometimes this rubs against private interests who may have land nearby, or may have been in the habit of using portions of these areas as, essentially, a private recreational ground. I guess the private interests

have to yield to the public needs to a reasonable degree. The Corps has dedicated itself to seeing that there is public access—and a fair opportunity to use these lakeshore facilities for the benefit of everyone.

People have different ideas as to what use they want to make of a water resource, so we have to have reasonable regulations: how many docks should be permitted, where they should be permitted, what are hazardous areas, and where can certain types of activities be conducted?

Unfortunately, many of our lakeshore projects were developed when there was very little pressure for recreation, and our concepts were considerably more relaxed. Now that the demand for recreation is with us, and has probably overtaken our regulations, we've got to move up to a higher level of management.

Another multiple use stems from public and congressional demands for increasing hydroelectric power production. Does the Corps intend to continue expanding existing facilities?

It is in the budget this year and will be for a good many years. We will expand existing facilities where provision has been made for additional turbines to be added and the need is there. In some cases, hydroelectric power also can be added to a dam or a lake facility that was built without any power capability. There are also opportunities at a few very attractive new sites, although they are probably limited. This application of our resources will receive the highest priority attention by the Corps in coming years.

I would say that we have come into a new way of looking at energy because of our shortages and the higher prices that are attached to energy today. This opens up a lot of opportunities that were closed in the past because they just were not economic to develop. Now that may no longer be true, and we will be exploring, for example, the opportunities for peaking power through pumped storage.

We will be looking at low head and run-of-the-river types of installations. I think we may be able to develop the technology to harness the enormous energy on rivers such as the Mississippi or the Missouri, which have enormous quantities of running water without much change in altitude.

"I don't want to see a destructive warfare between the modes of transportation . . ."

Another issue is transportation. What role do you see for waterborne navigation?

I would say that navigation has to be a very important part of any national transportation scheme. We're far short of having a plan that correctly portrays our national transportation policy today. We need to strive for a balanced plan that includes provisions for water, rail, highway, air and pipeline transportation.

When you speak of a "balanced plan," how would you compare the rail and highway modes to water transportation in achieving this balance?

We need all modes in a strong, workable condition to serve our national interests. We know that we have not developed the sophistication or the intensity of the water transportation mode that we should have to serve the needs of America. We are going to do more with water commerce, but that doesn't mean we are going to sacrifice the rail or highway modes to develop the water mode. Nor does it mean that the water mode should be sacrificed to the rail or highway modes. The rails are in serious operational, financial and structural difficulties in terms of maintenance of roadbeds, bridges and equipment—things that have to be improved. I don't want to see a destructive warfare between the modes of transportation which will render them all incapable of meeting national needs. A cooperative approach is the correct approach.

Some of the controversy focuses around application of user fees to waterway traffic to achieve this balance.

A great deal has been made of this particular point. I am finding that waterway users have had a very strong point of view against imposition of any user fees in the past, but I think this position has softened somewhat. That is not to say that they welcome or invite the application of user fees, because no one in his right mind would ask for an additional tax or cost to be laid on his operation. To me, the situation may be parallel to the development of our interstate highway system where, years ago, the truckers had user taxes laid on them, the proceeds of which were devoted to developing the interstate system. It resulted in enormous benefits to the trucking industry in the long run, and I see that same possibility down the line with respect to waterway users.

"A 12-foot navigational channel is not authorized in the upper Mississippi River."

These fees have to be applied fairly and we don't know the impacts. A definitive study has never been made which shows us who really ends up paying that bill. Surely, it isn't going to be the barge operator. It has to be passed on. We can't let economic competition between rail and water be the sole consideration in deciding that a punitive type of user fee should be put on waterway users.

Much of this has come up because of recent controversy over repairing Locks and Dam 26 on the upper Mississippi. What are some of the key issues?

Of the key issues that have emerged in the past several years, the first is environmental: whether or not the environmental impact statement which

had been prepared earlier by the Corps, and was local in its treatment of environmental concerns, was adequate.

The second is a technical one of whether or not the building of new locks and a dam is authorized by the Congress, and there are varying interpretations of that. In the past, the Corps has interpreted older legislation as giving the Secretary of the Army the authority to replace locks and dams whenever that is deemed essential, and we started off in that direction on Locks and Dam 26. Various groups have taken this issue to court. The court has said, "No! Specific authorization by the Congress would be required"—and that's the direction we are moving in now. We hope to take the matter to Congress this year to get such an authorization.

The third area of concern is economic competition between railroads and water for the handling of freight.

"It now takes over 17 years, on the average, for project completion."

That issue tends to center around the economic analysis of the project—what the benefits and costs will be. As to the methods of analyzing these benefits, the Corps is constrained by past decisions made by Congress that tell us exactly how navigation projects are to be analyzed. We do it on a rate basis and various economists can say there are other ways of doing it, but that is the way that Congress has said this is to be done.

It's most complex analyzing the rate savings, for example, in a situaton like Locks and Dam 26 on the Mississippi, which handles a huge volume of coal, petroleum products and grain moved up and down the river by thousands of individual shippers. Determining the rate savings is a very intricate process and we are using increasingly sophisticated analysis techniques.

We haven't completed our economic analysis of the situation. I expect that it may not be completed for some time, because the nature of this type of project is that it receives benefits over the 50 to 75 years that it extends into the future. Long range projections as to how much grain we're going to ship to Russia or how much coal we're going to move on the river become pretty tenuous that far into the future.

Environmental groups are protesting the rebuilding of Locks and Dam 26. Why?

Locks and Dam 26 has become sort of a buzz word, a rallying cry, among some of the environmental groups. They have gotten hung up on the idea that the building of a new Lock and Dam 26 brings into being a 12-foot navigational channel. Such is absolutely not the case. A 12-foot navigational channel is not authorized in the upper Mississippi River. It is not within the role of the Corps of Engineers to develop such a channel. It is not the desire of the waterway users to have a 12-foot channel. They have no equipment for it. They have no need for it. In fact, an economic analysis by the Corps some years ago showed the Congress that it is just not economically justifiable. We are in the process of trying to lay these facts about the upper Mississippi before the environmental people so that they really understand that is the case.

Moving on to a new area for the Corps, what is the purpose of the urban planning studies program?

The thought is to provide a software service for metropolitan communities —not the smallest communities without major problems, nor the huge communities that have pretty good planning capability, but the intermediate size communities that have water resources problems and lack the capability to analyze them. The Corps has gone into about 40 locations with efforts to coordinate planning by the local governmental entities in a metropolitan area in order to get them to think through their common problems on water supply, water distribution, getting rid of wastewaters, flood protection and whatever other water related problems they may have. It then remains for the local entities to decide what they want to do with the plans. As the first of these studies is completed this year, it will be interesting to observe the tangible results.

Doesn't the Corps also coordinate with a good many Federal and State agencies in many of its projects?

We are heavily dependent upon city, county, flood control districts, levee boards and State governments in all of our projects. This is very interesting because Corps projects take such a long time to be formulated, designed and constructed. It now takes over 17 years, on the average, for project completion. Philosophies and personnel within the local governing boards can change many times during that 17-year span. Sometimes one governor will say "go" and the next governor will say "stop." This is hard on a project where you are pouring concrete that is supposed to have a useful life of 100 years or so. We do spend a great deal of time in working with these local entities. In this respect, the Corps is ideally organized to accomplish this through our many district offices. We have a responsible district engineer in each office who is able to deal directly with the local and State governments.

Is there any way to speed up this 17-year process?

Much of that time span is uncontrollable by the Corps. A lot of our time has to be spent in meetings and discussions, and in informing the people. For example, in a flood control project you always encounter opposition between the upstream and downstream people, and you have to find agreement on a project that they both want. It takes a long time.

"Incidental to its other projects, the Corps of Engineers has built more railroad lines in recent years than anybody else, . . ."

Then, of course, just the ordinary engineering time required is substantial. We have to go through the congressional process two times, first for an authorization and then back again for an appropriation or a series of appropriations. Sometimes they are im-

mediately forthcoming and sometimes they are not.

Sometimes we have had delays because of environmental concerns. One of the problems with the NEPA legislation is that it legitimately brings out the environmental impacts, but it also gives individuals or groups a handle if they want to stop a project on technical grounds by saying: "Your environmental impact statement isn't sufficient." That requires going to court to have a judge decide. Even when the judge decides it is sufficient, a delay has taken place. That is an unexpected byproduct of the NEPA legislation, although I generally feel it has resulted in improved projects.

"Sometimes one governor will say 'go' and the next governor will say 'stop' . . ."

We'd like to dovetail the steps as much as possible and move these projects along: first, to meet the needs and expectations of people who want things done; second, to speed the day when the benefits begin to flow out of the project. Besides, it's a constant source of embarrassment to the Corps that inflation, which probably will be ongoing over many years, continues to escalate the costs—the more delay, the more the project costs.

Is the project still needed after all that time?

Hopefully, yes, because our original planning is done on the premise that it is a long term project. There could be changes, of course, that come along and render a project either insufficient or maybe not needed at all. Each project is reviewed annually during the appropriation cycle and there are instances where Congress, usually responding to a changed point of view from a Governor or someone like that, has decided that a project is no longer desirable, even after it has been started. Once started, we don't like to change or cancel a project, because it's really not the wisest use of our resources. We ought to try to anticipate these difficulties in advance to the extent that we can and place our emphasis on the really sound projects that are going to be valid for a long time.

Isn't there an existing process for actually deauthorizing projects no longer valid?

Yes, there certainly is, and I'm not certain this is understood by the public. A common myth says once the Corps gets an idea in its mind, it never gives up and never changes. That is just not correct. Circumstances do change. The Corps itself screens out a large number of proposed projects that it finds to be without merit. Sometimes projects are authorized and not funded for a considerable time. We then go back to the Congress and say: "This is not a project that is going to come together. Let's just take it off the books." Several hundred have been eliminated in that way in the past year or two. I'm sure that process will be ongoing.

Supposedly, the Corps image is changing. How do you see its future role?

In addition to a continuing role in the development and protection of our water resources, I see some possible new directions. We've spoken about some of them. There is a need, and we are beginning to venture into this field, for a total river-basin development concept. The plan developed by the Great River Environmental Action Team (GREAT) for the upper Mississippi River basin integrates environmental, engineering, navigation, fish and wildlife and other aspects into a composite program.

I see the possibility of a related role for the Corps of Engineers in the strip mine reclamation field. We don't as yet have national legislation in this area, but the Corps has been directed to study some water related aspects—acid mine drainage and that sort of thing. Reclamation is conceptually within the capability of the Corps.

The railroads are in real need of engineering help. It may well be that the Federal government will have to take a major role in the rebuilding of roadbeds and bridges. Incidental to its other projects, the Corps of Engineers has built more railroad lines in recent years than anybody else, so we have considerable competence there.

The Corps is gaining increasing respect as a conservation oriented organization. Our projects now require that the public interest be served fully by maintaining an equal balance between the economic development and environmental quality aspects. A specific charge from the Congress also makes the Corps responsible for the environmental protection of our wetlands and the "waters of the United States" against unwise or unnecessary destruction.

These tasks relate back to the fact that the Corps has continued to maintain a flexibility and capability to do everything asked of it by the Nation. We've done some interesting and diversified things in the past: from mapping the West, helping to stake out the railroads, and establishing Yellowstone and Yosemite National Parks to helping develop the atomic bomb and building the Panama Canal. All these have been within the competence of the Corps of Engineers, and I would predict we will be called upon for many new roles in the future. ■

Ground Water Problems with Oil Shale Mining in the Piceance Basin

by **John B. Weeks**
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Denver, Colorado

Underneath vast areas of Colorado, Wyoming and Utah lies the largest known oil resource in the world. Yet the United States is worried about a long-term shortage of energy. The problem is to find a way to reach this subterranean resource and convert it for the country's use without excessively degrading the region's water resources.

An estimated 1,800 billion barrels of oil are contained in known deposits of oil shale more than 10 feet thick and averaging more than 15 gallons of oil per ton of rock. These deposits lie buried within the geologic strata of the Green River Formation. About one-third, or 600 billion barrels, is contained in deposits that existing technology can convert into oil commercially. The potential of oil shale to alleviate the Nation's dependence on foreign oil has stimulated the Federal government and private industry to develop oil shale technology.

Prototype Leasing Program

In 1974 the Department of Interior leased four tracts of public land to private industry to determine the economic feasibility of producing oil from oil shale. Each of

these prototype leases covers a 5,100-acre tract, two of which are located in Utah's Uinta basin and two in Colorado's Piceance Creek basin.

Among the most serious difficulties facing the future of oil shale development in the Piceance basin are those related to the quantity and quality of the ground water. Thus, concern for environmental quality has been built into the prototype leases through stipulations that the lessees must collect baseline data for a period of 2 years before their final plans can be approved by the Department of the Interior.

The private industry lessees are being asked to include information not only on water quantity and quality, but also on air quality, geology, soils, vegetation, fish, wildlife, and historic and scenic resources. Data collection will continue throughout the development and reclamation phases of the leases to provide a basis for evaluating the environmental impact of prototype development. The decision to let future leases will depend, in part, on the results of this evaluation.

The Piceance Basin

The two tracts located in Colorado are situated within the basin drained by the Piceance and Yellow Creeks, both tributaries to the White River on the western slope of the Rocky Mountains. This 900-square-mile basin lies about 200 miles west of Denver and 60 miles north of Grand Junction, within an altitude range of under 6,000 to over 8,000 feet above sea level. Although annual precipitation averages 16.9 inches, the mean runoff to the White River is only 15,000 acre-feet annually, or about 0.3 inch. The remaining 16.6 inches are lost to the atmosphere by evaporation and plant transpiration.

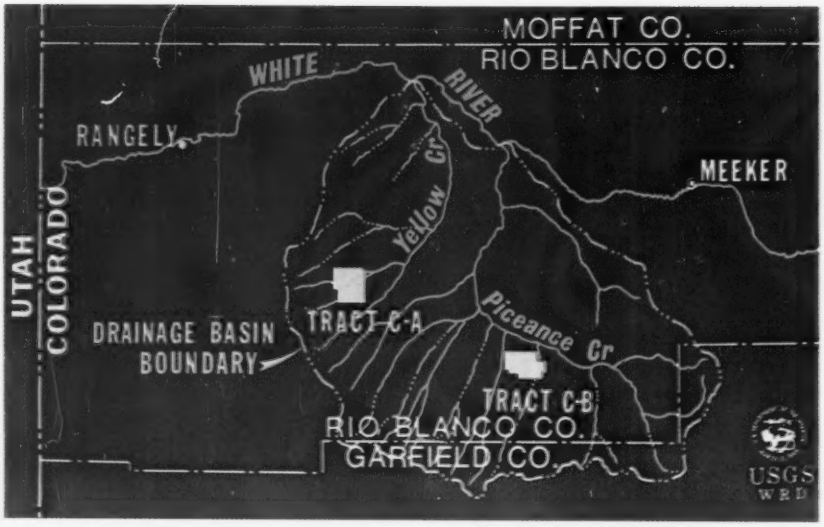
There are seven major types of vegetation in the Piceance basin. The predominant bottomland is sagebrush whereas the predominant upland cover consists of pinyon and juniper. Basin vegetation not only supports the largest migratory mule deer population in North America—estimated between 30,000 and 60,000—but also provides habitat for elk, bobcats, mountain lions, coyotes, black bears, wild horses and other animals.

Figure 1 illustrates the geology of the Piceance basin, showing its diagrammatic east-west cross section. This view of the basin shows it to be the site of considerable sediment deposition that probably began as early as 100 to 65 million years ago. Then, during the Eocene Epoch of 54 to 37 million years ago, crustal warping created a huge lake which covered much of today's northwestern Colorado and northeastern Utah.

When conditions made plant and animal life abundant, organic-rich layers were deposited as the organisms died and sank to the lake bottom. Gradually, younger sediments buried the organic-rich deposits and the lake eventually filled with sand, silt and clay carried in by

Green area locates drainage basin of Piceance and Yellow Creeks in northwestern Colorado.

Left—Road cut at left slices into the exposed Mahogany zone, richest of the oil shale strata in the Green River Formation. Scene is along Piceance Creek about 5 miles from its confluence with White River.



Prototype development tracts have been leased to private companies to explore possibility of extracting oil from shale.

Presence of North America's largest migratory mule deer herd wintering in or near Piceance basin is among environmental factors oil shale developers have been asked to consider.

streams. The weight of these overlying sediments consolidated the underlying deposits. This action formed sandstone, shale and marlstone layers of the Green River and Uinta Formation, converting the organic material to a form of solid hydrocarbon called *kerogen*.

As illustrated by figure 1, the Piceance basin includes a sequence of sedimentary rocks. The Uinta Formation consists of sandstone and marlstone beds that rest conformably on the Parachute Creek Member of the Green River Formation. The Parachute Creek Member is made up of kerogen-rich marlstone beds. Because of the laminated structure and dark color resulting from the kerogen, the marlstone has the appearance of shale and is commonly called oil shale. The Garden Gulch and Douglas Creek Members of the Green River Formation underlie the Parachute Creek Member and consist of sandstones and marlstone with little or no kerogen content. On the eastern margin of the basin, a near-shore sequence of sandstones is called the Anvil Points Member. The Wasatch Formation, which consists mostly of multicolored clay, shale, and lenticular sandstone beds, underlies the Green River Formation.

The Parachute Creek Member of the Green River Formation is the oil-shale-bearing part of the section.

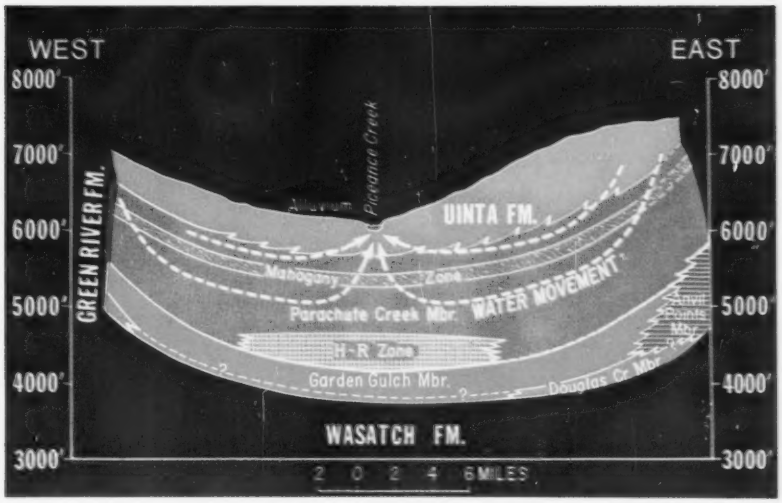


Figure 1—Diagrammatic section through underground formations shows geologic relationships and direction of ground-water movement. Parachute Creek Member of Green River Formation contains zones richest in oil shale.

Within this member, the Mahogany zone is the interval containing the richest oil shale. In the central part of the basin, the H-R or high-resistivity zone is also an interval of rich oil shale.

The porosity and permeability of the section developed from fracturing and the solution of sodium minerals that were included in the Parachute Creek Member at the time of deposition. Fracturing is related to the kerogen content of the rock. The higher the kerogen content, the less susceptible the rock is to fracturing. Consequently, the Mahogany zone is generally less permeable than the rocks immediately above and below. Similarly, the H-R zone has little permeability and the soluble minerals are in place. The top of the H-R zone is the base of the permeable section. Where the H-R zone is not present, the top of the Garden Gulch Member, which has much lower permeability than the overlying Parachute Creek Member, is essentially the base of the permeable section.

The Aquifer System

The less permeable Mahogany zone creates two separate aquifers, or water transporting layers, within the system. The Uinta Formation and that part of the Parachute Creek Member within the Green River Formation that lie above the Mahogany zone constitute the upper aquifer. The lower aquifer consists of that part of the Parachute Creek Member below the Mahogany zone. Depending on location, either the top of the H-R zone or the Garden Gulch Member forms the base of this aquifer system.

The principal recharge period is during the spring when snowmelt saturates the soil and water infiltrates into the saturated zone. In the summer, evapotranspiration demands greatly exceed precipitation and little or no recharge occurs. The annual recharge is estimated at one-half inch over the basin or about 26,000 acre-feet. The principal recharge area is along the basin margins above an altitude of about 7,000 feet. Water infiltrates into the upper aquifer and moves toward the center of the basin where it is discharged to Piceance Creek and Yellow Creek valleys as streamflow and evapotranspiration. In the recharge area, water also moves downward through the Mahogany zone to the lower aquifer, where the water moves laterally to the center of the basin and then upward through the Mahogany zone to the upper aquifer.

Piceance Creek valley is the principal ground-water discharge area in the basin. About 80 percent of the ground-water discharge occurs in Piceance Creek drainage and 20 percent in Yellow Creek drainage. About 80 percent of the annual runoff from the basin is derived from ground-water discharge.

Ground-Water Quality

Water percolating through the lower aquifer is actively dissolving minerals, principally nahcolite (sodium bicarbonate) and halite (sodium chloride). As a result, large differences in water quality have developed between the aquifers.

Sodium and bicarbonate are the dominant dissolved constituents in water from both the upper and lower aquifers. Water in the upper aquifer, as shown in figure 2, generally contains less than 2,000 milligrams per liter dissolved solids[1] and low concentrations of trace elements, except where the water quality is affected by water moving upward from the lower aquifer. Water in the lower aquifer, as shown in figure 3, contains more than 30,000 milligrams per liter dissolved solids (which is comparable to ocean water) in the north-central part of the basin. The fluoride concentration in the lower aquifer is generally greater than 10 milligrams per liter, which is unusually high, and has been measured as high as 95 milligrams per liter.

[1] For comparison, the U.S. Public Health Service recommends the concentration of dissolved solids in public water supplies should not exceed 500 milligrams per liter. See publication 956, "Drinking Water Standards," 1962.

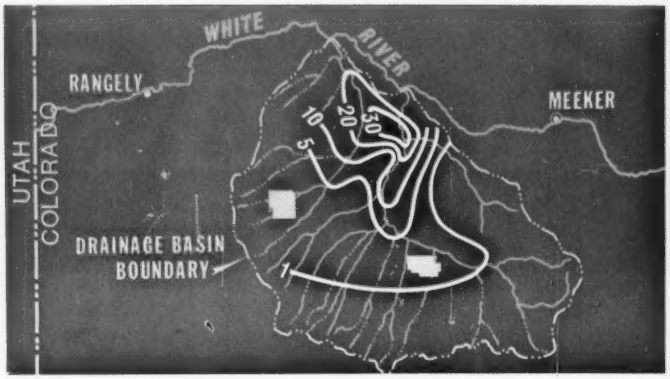
Appropriately called Alkali Flats, this reach of Piceance Creek derives its name from sodium mineral deposits left by evaporation of ground water.

Figure 2—Concentration of dissolved solids in upper aquifer (above Mahogany zone) is generally less than 2,000 milligrams per liter.

Figure 3—Concentration in lower aquifer (below Mahogany) exceeds 30,000 milligrams per liter in northern part of basin.

Figure 2

Figure 3



Many trace elements have been found in relatively high concentrations in water samples from the lower aquifer. In particular, high concentrations of barium, boron, and lithium are associated with the sodium-bicarbonate brine in the northern part of the basin. Concentrations as large as 13, 320, and 40 milligrams per liter, respectively, have been found.

Obviously, ground water from the lower aquifer could create severe water quality problems in developing an oil shale industry in the Piceance basin. However, the prototype lease tracts are located in the southern part of the basin, where water quality problems should be minimal.

Problem Solving By Computer

The lessees of both tracts in the Piceance basin have announced their intention to use ground water produced from dewatering the oil shale mines to supply the water necessary to process the oil shale and dispose of the spent shale. Spent shale is the residual rock remaining after retorting, a process which heats crushed oil shale under pressure to about 900° Fahrenheit. This vaporizes the solid hydrocarbons in the rock. The vapor is collected and cooled to obtain a "crude" oil which can be refined into most of the common petroleum products.

A 50,000-barrels per day (bpd) retort, which is the initial production goal for each tract, requires about 12,000 acre-feet of water per year, enough water to supply a city of 50,000 people. About half of this water will be bound in the spent shale (during surface disposal) that would result from the daily retorting of 65,000 to 90,000 tons of oil shale by each 50,000-bpd unit.

A computer model of the ground-water flow system in the Piceance basin has been developed by the U.S. Ge-

The U.S. Geological Survey has been studying the water resources in the Piceance basin since 1958. This core hole, located on one of the prototype lease tracts, is among those reentered to obtain ground-water data.

ological Survey in cooperation with the Colorado Department of Natural Resources to evaluate the effects of mine dewatering on the ground-water system. Results of studying the estimated dewatering rates for hypothetical oil shale mines in both tracts indicate tract C-a will not be able to meet the annual water demand of 12,000 acre-feet for a 50,000-bpd retort after the first few years of dewatering. However, the mine at tract C-b will produce water in excess of the demand throughout the life of the mine. Thus, tract C-a could be faced with a water shortage while C-b has a problem of water disposal.

The most obvious solution would be to use the wastewater from C-b to offset the deficiency at tract C-a. Other methods of obtaining additional water at tract C-a include importation of water from outside the basin, increasing pumpage from the wells used to dewater the mined area, or developing an auxiliary well field elsewhere in the Piceance basin.

Water pumped from the mines will come from water normally stored in the aquifers penetrated by the mines and ground water intercepted prior to discharging into stream valleys at the surface. Estimates based on the model study indicate 0.5 million acre-feet will be removed from storage by dewatering the two hypothetical mines for a period of 30 years. The total volume of water in aquifer storage may be as large as 25 million acre-feet.

Dewatering operations will only slightly affect ground-water discharge in the Yellow Creek drainage. However, if the dewatering rates predicted by the model are correct, ground-water discharge will cease in a 10-mile reach of the Piceance Creek near tract C-b within 30 years. The result would be an increase in the concentration of dissolved solids in Piceance Creek as well as a reduction in the streamflow available to downstream users.

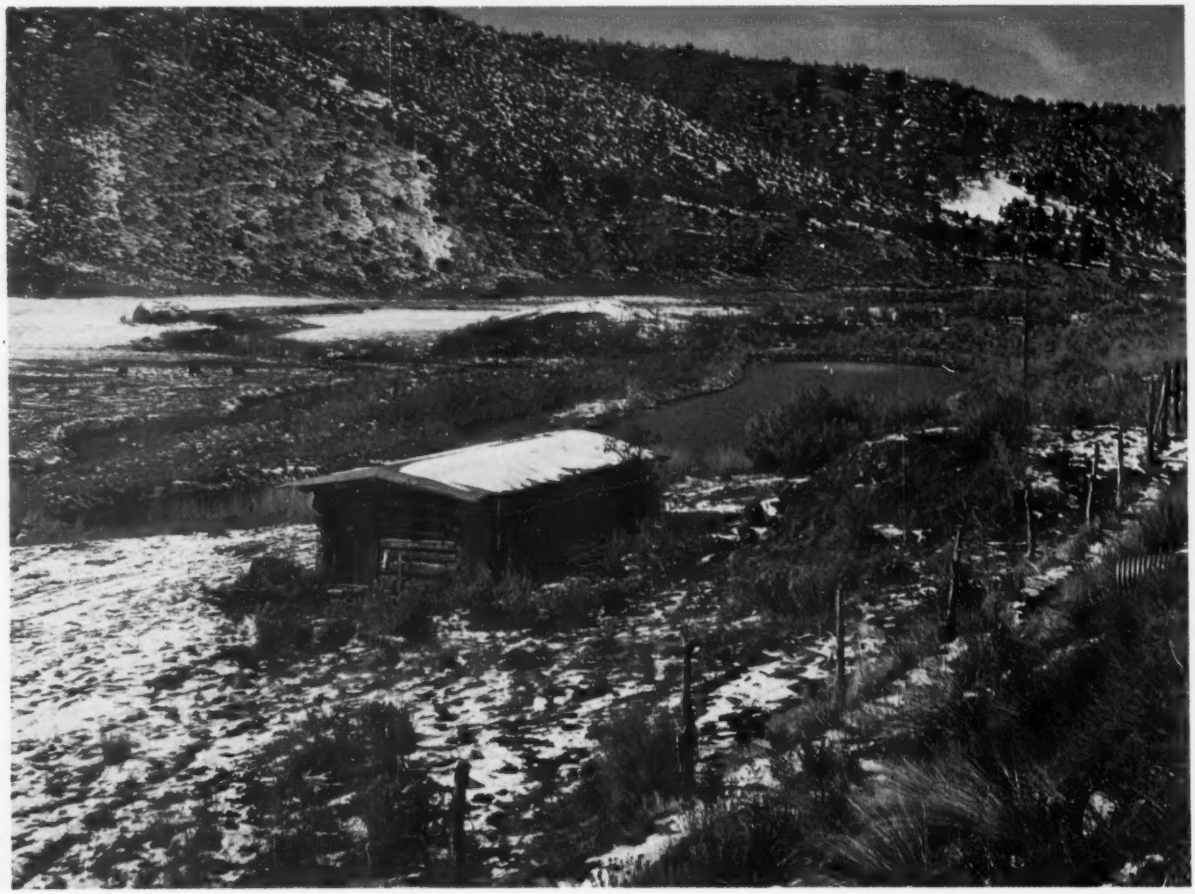
The model study assumed that the hypothetical mines completely removed the Mahogany zone which now separates the upper and lower aquifers. The assumption maximizes the pumping rates required to dewater the mines and is valid at tract C-a, where an open-pit mine will be developed. At tract C-b, however, oil shale will be obtained from an underground mine within the Mahogany zone. Therefore, the dewatering rate could be considerably less than estimated, depending on the permeability of the mine floor and roof. This may not necessarily be the case, though, since the recovery percentage is important to the economics of developing the oil shale as an energy resource. Thus, the entire Mahogany zone (as well as deeper beds of oil shale) will probably be mined and large discharge rates will eventually be required to dewater the mine at tract C-b.

Excess water will be produced at both tracts during the initial phase of development. At tract C-a, the overburden will have to be dewatered and stripped away to reach the oil shale resting at depths of 50 to 500 feet. At tract C-b, underground mine entrances will have to be constructed through a thousand feet of water-saturated rock to reach the shale deposits. Since the retorts will not be operating during this phase of development, demand will be at a minimum and water will have to be wasted. What is done with the wastewater will depend on its quality.

The quality of the water pumped from the oil shale mines will deteriorate as dewatering continues into the future. At the start, the concentration of dissolved solids in the discharge water at both tracts is expected to be about 1,000 milligrams per liter. As dewatering continues, ground water containing higher concentrations will flow toward the mines. Based on the dewatering rates estimated by the computer model, the concentration of dissolved solids in the mine discharges could reach 5,000 milligrams within 30 years.

The simplest way to dispose of this wastewater would be to discharge it to Piceance and Yellow Creeks. How-

Spring fed irrigation and stock watering ponds, such as this one on ranch near prototype lease tract, could lose ground-water supply following prolonged mine dewatering.



ever, because State and Federal statutes prohibit degradation of stream water quality, other methods of disposal are under consideration. These methods include evaporation, chemical treatment to improve the wastewater quality sufficiently to permit its discharge into streams or sale to water users, reinjection into the aquifers elsewhere in the basin, or pipelining the wastewater to some place where it can be used without further treatment.

All of these methods have their economic and technical difficulties. Whereas the quantity of wastewater produced during prototype development of the oil shale resource will not be excessive, the present cost of disposing of wastewater in an environmentally acceptable manner should not overwhelm the economics of recovering the shale oil. However, this may not be the case when full scale development gets underway in the Piceance basin.

Full scale development of this resource will probably follow if prototype development proves to be both environmentally and economically successful. As development moves toward the northern part of the basin, larger pumping rates will be required to dewater the mines. Eventually, the concentration of dissolved solids in the mine discharge will exceed 30,000 milligrams per liter and the resultant wastewater disposal problems could make further development either environmentally unsound or uneconomical. For the immediate future, however, the concentrations in water produced by the prototype mines probably will not exceed 5,000 milligrams, and the quantity of ground water produced during mine dewatering should be adequate to meet initial demands.

Wise application of technology will be the key to unlocking this vast underground resource for public consumption. Oil shale deposits represent a potential source of energy that could meet the Nation's demand for oil for decades to come and, as such, play an important role in helping shape the country's future growth. It will be necessary to find a balanced approach toward developing shale oil for the Nation without permanently damaging the environment of the region providing this resource.■

SNETTISHAM Challenges the Alaskan Winter

by **Lyman L. Woodman**
Public Affairs Officer
Alaska District

About 28 air miles south of Juneau, in southeastern Alaska's Panhandle, lies a most unusual project. It is the first Army Corps of Engineers constructed hydroelectric plant to be encased within a chamber of solid rock, an engineering feat for which the Corps received the Chief of Engineers Distinguished Design Award in 1974.

Although an award recipient, based on its neatly concealed underground powerhouse design, the Snettisham project has had that award somewhat tarnished by several failures of the 138,000-volt transmission line that carries its electrical energy along the shores of Stephens Passage into the capital city of Juneau. A 6-mile stretch of transmission line emplaced along Salisbury Ridge has proved particularly vulnerable to the severe icing and wind conditions for which that area is noted.

This unique subterranean powerhouse is located at the head of Speel Arm, an estuary of the Speel River that flows into a 10-mile-long navigable fjord that eventually widens into Port Snettisham. Vessels enter Port Snettisham off the Stephens Passage along the famed "Inside Passage" of the Panhandle that permits access to the city of Juneau and other southeastern Alaska ports by seagoing ships.

Thus, the Snettisham project actually lies close by the highly photogenic Alaska Marine Highway and is set among steep 5,000-foot mountains covered by the dark greys and greens of the Sitka spruce and hemlock forests which grow so thickly in this part of Alaska, where the annual precipitation touches the 150-inch mark. A background of blue-white glaciers contributes to the spectacular view. The rugged terrain and abundant rainfall combine to create a natural setting for the development of hydropower.

A first attempt at development occurred in 1913 when a mining company applied to the U.S. Forest Service for permission to construct a hydropower project within the Tongass National Forest. The next 49 years were spent conducting explorations, compiling reports, writing appraisals and reappraisals, launching feasibility investigations, filing memos of agreement and holding hearings. The culmination of all this activity was a 1962 congressional authorization to construct the Snettisham project.

Most exciting of all the elements in the general concept was a plan to tap Crater and Long Lakes for the water to generate the power. Both lakes are perched high above the near sea-level powerhouse location. A 45-mile transmission line—including a section of submarine cable under 650-foot-deep Taku Inlet—was to carry the electrical power to a terminal substation near Juneau. From this point the Alaska Electric Light and Power Company was to handle distribution under a contract with the Bureau of Reclamation's Alaska Division (now the Alaska Power Administration). Although only 28 air miles from Juneau, a circuitous 45-mile long sea-level route was selected to avoid the deep snows and heavy icing conditions anticipated by using a more direct routing with higher elevations.

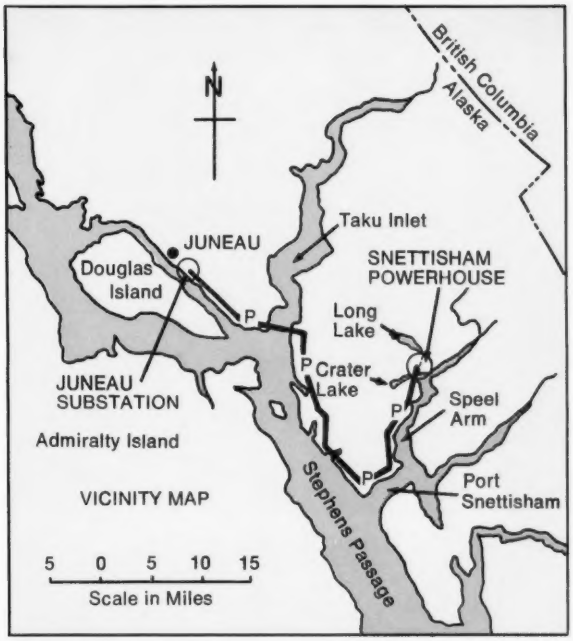
The plan was to proceed in two phases. Under Plan I, only one of the two lakes would be tapped to power two generators that would produce 46,700 kilowatts between them; Phase II would tie in the second lake and add a third generator as demands for power increased.

An 800-foot-long concrete dam was planned to raise Long Lake, the first to be tapped, from 815 to 895 feet above sea level. Designing this dam became an engineering challenge because it had to be constructed atop an existing natural ridge of granite bedrock left behind when an ancient glacier carved out the bed of the lake eons ago. This natural barrier already partially blocked the lake's outlet into Long River.

During the engineering phase it was determined that construction of the dam was not essential to meet early power requirements in Juneau and vicinity. The construction of the dam was deferred, therefore, and only a 5-foot-high concrete weir has been built for now.

The plan of operation called for the gates at an underwater intake structure to be opened, allowing water to surge into the powerhouse through an 8,000-foot power tunnel and then into a 400-foot penstock leading to the dual generators. The power intake structure and power tunnel could not be built, however, without first lowering the surface of Long Lake 135 feet through a diversion tunnel. This required drilling a 600-foot-long, 10-foot-wide diversion tunnel to bypass the lake's outlet to a point farther downstream on Long River.

This need to drain part of Long Lake led to employment of a unique and somewhat spectacular technique called the Norwegian Lake Tap. This deceptively simple method of draining a lake consists of starting at an outlet point downstream and angling a tunnel upward along a heading calculated to strike the lake at the level to which



Underground powerhouse and connecting tunnel used to tap water from Long Lake lie at head of 10-mile long fjord off Stephens Passage.

Granite bedrock partially blocks Long Lake outlet, creating natural spillway. (Below and right)

the water surface was to be lowered. Boring was stopped at a point where only a few feet of rock separated the head of the tunnel from the lake. Multiple holes were drilled for insertion of explosives into the face of the remaining rock to pop the "plug" and, in so doing, "tap" the lake.

For years the Snettisham project was an off-and-on affair. Meanwhile, the small diesel generators serving Juneau were not only getting old, they were deemed inadequate to meet the increasing power needs of a city facing a 9 percent annual growth rate. Even though thousands of dollars had been invested in engineering design and test drillings, not until almost a year after the Juneau "brownout" of Christmas Day 1965 did preliminary funds become available with a congressional appropriation of $750,000 in October 1966.

The first actual construction contract, for over $7 million, was signed by Alaska District Engineer Col. Clare F. Farley in July 1967, but funds were frozen that fall. Part of a construction season was lost and the project completion date was set back a year. The bids called for private construction of a camp near the powerhouse area, access roads, an airstrip, a harbor for seagoing barges and the drilling of a diversion tunnel for the lake water. Although seagoing barges could bring equipment to the main camp via Port Snettisham and

Speel Arm, Long Lake was accessible only by helicopter or float plane.

"Pulling the plug" 130 feet below the surface of mountain-ringed Long Lake took place July 16, 1969 under the watchful eyes of Christian Groner of Oslo, Norway, internationally recognized authority on underground construction who had been retained as a consultant. The 9-foot thick plug was blown out by 506 pounds of dynamite placed in 82 holes. Lowering the lake level permitted construction to begin on the power tunnel and intake structure.

The original timetable called for initial power service in October 1972, but fund cuts—eventually reducing an $8.6 million request to $1.2 million—forced a temporary shutdown in September 1969 and postponed the ex-

Drilling pattern at face of diversion tunnel constructed for purpose of lowering Long Lake.

First underground powerhouse built by Corps sits inside quartz diorite rock chamber. Space in front is for installation of Phase II generator.

Design of personnel (right) and vehicle entrances to powerhouse preserves natural setting. Peaked roofs protect entrances from snowslides.

Midslope routing of transmission line reduces visibility from Alaska Marine Highway.

pected power-on-line date for a year. Work resumed several months later and the Alaska District was able to call for bids on the main contract. This work included construction of the power tunnel, intake structure, surge tank and penstock tunnel and the excavation of an underground powerhouse chamber measuring 175 by 38 by 72 feet—a "first" in Corps history.

The decision to go subterranean was based on a value engineering study of comparative costs with an outside plant, design possibilities and the advantage of hiding the installation from view, thereby helping to maintain the indigenous scenic-wildlife quality of the area. Besides saving approximately $1.3 million, results of this action were the creation of a more pleasing underground work space for the operating and maintenance crews and avoidance of the need to disturb a natural biological refuge on the surface.

Today, the presence of a large powerhouse can hardly be detected, even from a relatively short distance. Specially designed access and service entrance tunnels blend into the mountainside. Their sharply peaked roofs protect the entranceways from winter snowslides.

Another part of the plan was revised due to excessive cost. In the winter of 1967, a new district engineer, Col. E. L. Hardin, Jr., announced that consideration was being given to an Alaska Power Administration request to transform the 13,800 volts of alternating current to be generated at the power plant into 67,000 volts of direct current for ease of transmission by underground cable through two single-conductor submarine cables. The direct current would be converted back to alternating current at the substation. The reason given was that the area's steep slopes, numerous avalanche sites and severe storm conditions not only precluded construction of overhead lines and the access

Low profile design of substation preserves beauty of skyline.

Aerial transport protects environment from damages associated with normal ground construction practices.

roads to service them, but the extended periods of inclement weather seriously restricted helicopter access.

Bids on the supply and installation of the direct current system were invited in June 1968. The following April Colonel Hardin announced that only one firm had submitted a proposal and that if—after analysis and evaluation—the design proposal met requirements, procurement would be negotiated. The sole bidder, however, withdrew its proposal early in 1970 due to technical difficulties and after determining that its bid of $20.6 million would be much more expensive than the alternative system. That decision put Snettisham back into transmitting alternating current, which would have to be routed through the Tongass National Forest along the shores of Stephens Passage.

The environmental implications of stringing overhead transmission wires in this terrain were brought out in a May 1970 public meeting held in Juneau by Colonel Hardin. Two possible routes were discussed. The over-the-mountain route, he explained, had been discarded because of the great difficulty in maintaining an overhead line against the high winds and heavy snows common to the area. The second route, the one chosen, was to be placed at a lower elevation. Although just above the beach, it would be located behind natural terrain features and below the skyline in order to conceal the route as much as possible from the view of travelers along the Stephens Passage shipping lane.

Clearing of the route was started in July 1970. As the route was laid out the area was scouted for eagle nests to avoid disturbing these birds during construction of the line. In the interest of protecting the environment and preserving the natural beauty of the forest, the clearing was restricted to a narrow work trail and only those trees were cut that could have endangered the power line had they fallen onto the towers, conductors or guy wires. The result was a scalloped right-of-way. Helicopters became the prime movers, since the use of heavy construc-

Better than 200-mile an hour winds and heavy icing toppled transmission towers along exposed Salisbury Ridge. Temporary wooden poles were used to restore lines.

tion equipment was not permitted along most of the route.

Only one departure from the preferred alignment occurred. This was a 6-mile-long stretch rising above the tree line and crossing Salisbury Ridge at an elevation of 1,850 feet. Although part of the over-the-mountain alternative previously abandoned, this routing was encouraged by the U.S. Forest Service and the city administration of Juneau to reduce tree cutting and exposure to public view.

By September of 1970 construction was already 18 months ahead of schedule, with 220 men working around the clock, and the power tunnel was holed through "in the dry" [1] in 1971 after 252 days of continuous work. Value engineering studies of the area geology showed that much of the 8,500-foot tunnel could be left unlined due to the hardness of the quartz diorite rock through which the tunnel would be drilled. This knowledge eliminated the need for considerable steel and concrete work, which saved about $1.5 million. Most of the tunnel, about 87 percent, did not require lining and measures 13.5 feet across, whereas the lined part of the tunnel is only 11.5 feet wide. After completion of the intake tower and power tunnel, a concrete plug was installed in the diversion tunnel.

It was now late in 1971 and construction emphasis shifted to completion of the powerhouse inside the mountain and the Juneau substation at Thane. The powerhouse construction contract was more than $3.7 million. Construction of the substation cost $1.5 million. Its low profile design, including the yard transformers and power lines, was the result of a deliberate effort to preserve the beauty of the skyline. A few months later, a $5.7 million bid won the contract for first stage development of the transmission line between the powerhouse and substation.

[1] *"In the dry" means the lake had been lowered below the tunnel entrance, so no water would gush through when the tunnel was opened to the lake.*

Building the transmission line was an aerial operation from beginning to end in order to protect the environment from the ground abuse of heavy construction equipment. The aluminum towers, anodized green to blend in with the tall trees of the forest, were assembled at the construction camp and flown by helicopter to their erection sites. The dull finish on the aluminum transmission wires and the light grey insulators helped make the total installation fade into the forest background. Replacement towers tend toward a grey-black that more closely resembles the true color of these dense woods.

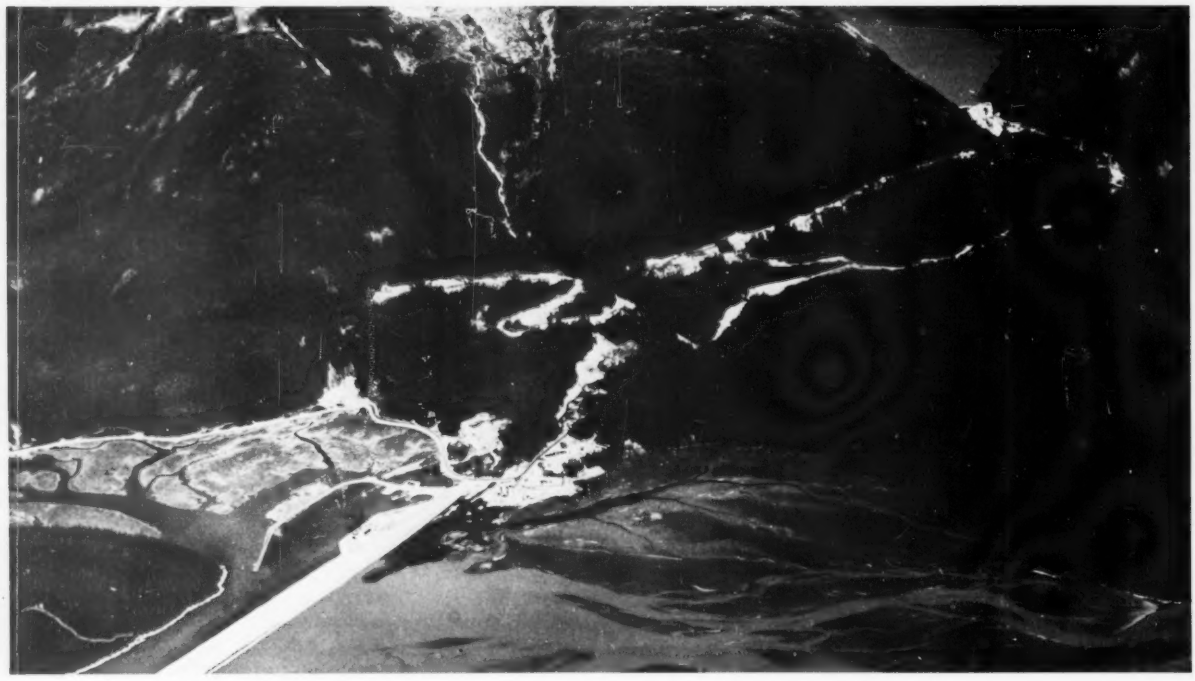
The Juneau Chapter of the Sierra Club praised the Corps for its environmentally conscious designs, but the helicopter pilots complained about the transmission line's low visibility from the air and some citizens felt the Corps was "going too far on the aesthetics."

Another contract for $1.5 million covered the supply and the laying of four parallel submarine cables that carry the transmission line 15,000 feet along the bottom of Taku Inlet, which intersects with the Stephens Passage a few miles south of Juneau.

The substation at Thane was energized on October 29, 1973 and system testing began two weeks later when Col. Charles A. Debelius, then the Alaska District Engineer, ordered the switch thrown. That fall, responsibility for operation and maintenance of the project was turned over to the Alaska Power Administration.

Problems occurred almost immediately when, during early 1974, a combination of heavy icing and record breaking winds toppled three towers and damaged others along the exposed section of line crossing Salisbury Ridge above the treeline. Corrective action temporarily restored the line over a 2-mile stretch of the ridge route by placement of 32 sets of poles, each set containing 3 poles each independently anchored by 12 guy wires. Despite the fog, rain, low clouds and high winds that repeatedly delayed the work, Snettisham

Underground entrances are located directly behind boat basin and airstrip extending into tidal flats of Speel Arm. Long Lake is at upper right.



was servicing Juneau again by October 17, 1974.

That winter was equally hard. High winds again caused another outage for the capital city in November. Anemometers capable of recording wind velocities up to 200 miles an hour failed atop Salisbury Ridge and the severe weather prohibited access by repair crews.

At a March 1975 public meeting Colonel Debelius outlined a plan to permanently relocate the Salisbury Ridge segment to a lower elevation. Although tree clearing would affect the beauty of the forest slope visible from Gastineau Channel, every attempt would be made to minimize scenic degradation. Recognizing the disappointment this intrusion of civilization would bring, Colonel Debelius reminded those present that the primary objective of the Snettisham project was to provide the residents of Juneau with a reliable source of power.

It was recommended that the replacement line for the Salisbury Ridge segment be run through the Tongass National Forest between the 200- and 700-foot elevations on a line roughly paralleling Gastineau Channel. The new route, as agreed upon by the U.S. Forest Service, traverses the midslope timbered area along the mountain overlooking the channel. As before, certain stipulations were added to make the new route as aesthetically acceptable as possible, since the mountain slope selected is in full view of waterborne travelers on Gastineau Channel.

On March 1, 1976 the district awarded the new route construction contract to a logging and transmission line construction firm with extensive aerial experience. Using the heavy-lift capability of a Sikorsky Sky Crane dual-rotor helicoptor, timber cutters are being brought in and cut logs brought out by airlift. Helicopters are used also in all construction work, including placement of tower footings, erection of the charcoal grey towers and stringing the power lines.

The transmission line towers that were built on the original route at lower, more protected, elevations are subject to other types of attack from the severe Alaskan winters. Early in 1976 another outage occurred as one tower in that part of the line between the powerhouse and Taku Inlet was knocked down and several others damaged by an avalanche that left the tower foundations under about 30 feet of snow. The Alaska Power Administration contracted with a helicopter company for aid in replacing the wrecked tower. This latest power outage lasted about 20 days.

The ever present danger from snow accumulations is being researched by an Alaska District hydrologist who has installed devices to measure snow movement along the transmission line to determine the effects of snow creep pressure on the towers. The information being gathered will be used in the design criteria for future line construction.

Phase II will be the next step in the long range plan for the Snettisham project. This involves tapping the waters of Crater Lake and adding a third generator in the underground powerhouse at such time as increasing power demands justify an expansion. Based on a current analysis of that demand for Juneau and its environs, it appears that Phase II power will not be required before 1985 at the earliest.

Meanwhile, merely keeping Phase I operating continues to test the mettle of men and material in their constant battle with the cold and winds, the ice and snow of the Alaskan winter. ■

Reorganizing Pollution Control in the U.K.

by **Ronald Toms**
Chief Scientific Officer
Wessex Water Authority

Borrowing a page from the management manuals of private industry, the United Kingdom reorganized its total concept of pollution control under a new corporate management image two years ago, and the results are beginning to show.

The problem faced by the United Kingdom is that of being one of the most densely populated countries in the world, with about 97 percent of that population having a piped water supply and about 94 percent connected to sewage collection and treatment facilities, most of which include secondary biological treatment processes.

Even though the demand for water is not as high as in the United States, the rivers providing the water are comparatively small and, because of population density, extractions from the lower reaches contain sewage effluent discharged farther upstream. The shortage of sufficient dilution water for many of these discharges has made a high degree of sewage treatment important since 1850, following introduction of the water closet in the early 19th century. Secondary biological treatment has been commonplace in most towns since the 1920s. More recently, the increasing proportion of effluent has meant a growing requirement for tertiary treatment—in the form of microstrainers and sand filters.

Nutrient removal is not yet as important, because the relatively short rivers and absence of many large lakes means deoxygenation through organic decomposition of the effluent is still more serious than eutrophication.

However, with increasing development of reservoir storage, problems with nutrient loadings are becoming more significant.

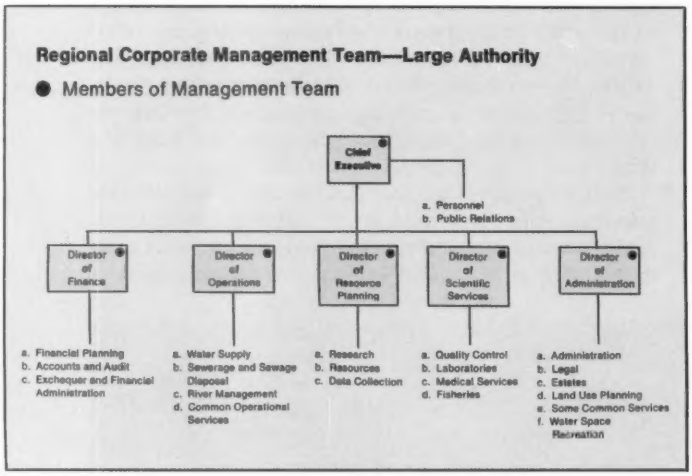
The Acts

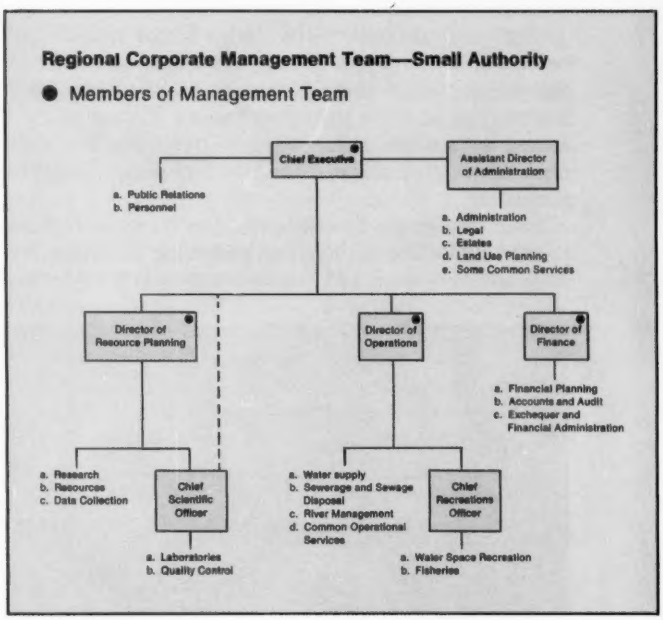
As the control of pollution became an ever increasing problem in more densely populated England and Wales, the United Kingdom was forced to undertake a drastic upheaval of its outmoded regulatory system. Until the Water Act of 1973, sewage treatment had been managed by some 1,393 local authorities, water supply was controlled by 157 separate authorities and 29 different authorities managed the various rivers. The Water Act of 1973, which became effective April 1, 1974, replaced these autonomous entities with a new corporate management structure by establishing a Welsh National Water Development Authority and nine regional water authorities to cover all of England. Each authority was given almost complete powers over the water cycle in its own area.

The 1973 Act combined wastewater collection, sewage treatment, river and water resource management, treatment and supply of public and industrial water, and included fisheries and water recreation as integrated components of a comprehensive management system under the control of a single authority.

Ten regional water authorities have been managing Welsh and English water resources since 1974.

Makeup of corporate management team varies between large and small regional water authorities.





More in the character of modern corporate entities, these 10 new authorities are powerful enough to adopt the industrial type of outlook required to control all aspects of the water cycle: producing, treating and supplying clean water—then treating the resulting sewage. As an additional public service, they also exercise control over river pollution and the general aquatic environment.

The powers of these regional bodies to control pollution are laid down in existing legislation such as the Rivers Acts of 1951 to 1961 which give the authorities control over the quality and quantity of all discharges of trade (industrial) waste and sewage effluent to non-tidal waters as well as new discharges to controlled tidal waters—mainly the estuaries. These powers are applied through *consent conditions*, which are likely to include quality limits on any discharge, together with maximum flow rates and assurance that samples will be taken.

The control over the quality of a discharge applies to grab samples rather than any attempt to measure the

This type of industrial discharge will be controlled once the Control of Pollution Act becomes operative.

A Control of Pollution Act was passed in 1974 that superseded much of the earlier pollution legislation, dating as far back as the Rivers Pollution Prevention Act of 1876. Passage of that first act was helped materially by the condition of the Thames outside the Houses of Parliament at the time. The river had become so putrid that lime had to be placed outside Parliament's windows to absorb the noxious odors. Subsequently, various other acts were passed. The next major step forward, however, came with passage of the 1948 River Boards Act which set up 32 river boards in England and Wales. Each of these boards was responsible for managing pollution prevention, land drainage and fisheries improvement in one or more river basins. These boards were replaced by the 10 regional authorities established in the 1973 Water Act.

In addition to superseding earlier legislation, the 1974 Control of Pollution Act extends the powers of the regional authorities to include all discharges to estuaries and the sea, as well as the control of boat discharges. It also contains increased powers to measure

Multiple uses of Bristol Avon River by city of Bath makes pollution control a difficult and challenging task.

total loading of impurities over a period of time. It is not considered practicable, for legal purposes, to assess the quality of a variable effluent other than by "spot" sampling at a random instant. Offenders can be prosecuted and fined up to £200 ($420).[1] Although this sum has been criticized as inadequate to deter polluters, experience has shown that the stigma attached to prosecution for pollution, and the subsequent publicity, is a far greater penalty.

the quality of discharges, to require that discharges not have an effect on the flora and fauna of a watercourse, and to tighten control over land activities that may have an effect on ground-water quality.

A particularly significant feature of the 1974 Act is the requirement that all consents, details of samples and any subsequent action taken by a water authority will be made available for public scrutiny, and that any member of the public can commence legal proceedings if the discharges are unsatisfactory. This includes an action against the water authority itself should its own

[1] *Value of pound has declined since Mr. Toms wrote this article.*

Country town sewage works taken over by Wessex Water Authority shows deplorable condition common to many rural works at time of national reorganization.

discharges fail to comply with the consent conditons established.

The 1974 Act has not yet become fully operative, since the water authorities could be prosecuted immediately as a result of the considerable number of unsatisfactory sewage works recently acquired. Complying with the new act will require a considerable expenditure on the treatment of sewage and trade waste to put these problems right. Thus the coming into operation of the new act will be an exercise in gradualness.

The Water Authorities

The structure of these bodies was put together by a committee chaired by Sir George Ogden. The result was an organization based on multifunctional lines under the control of a chief executive. This chief executive is supported by a small corporate management team whose purpose is to implement policy. Each authority consists of a simple majority of district and county council representatives joined by several ministry-level appointees whose knowledge and experience qualify them as water quality specialists. The structures proposed by the Ogden Committee varied, depending on whether the authority was considered large or small.

In general, the structures proposed have been implemented with only slight variations. As for the multifunctional operations within each authority, there is a general move toward separating the varied responsibilities into a small number of operating divisions, each under the control of a divisional director and with a staff covering as wide a variety of duties as possible.

An advisory National Water Council also was formed to coordinate activities among the water authorities and to mediate between the authorities and the government. Under the chairmanship of Lord Nugent of Guildford, the council consists of the 10 chief executives from each of the water authorities and several governmental appointees. This body has been most active in guiding the radical restructuring of the water industry, which is showing signs of considerable success after 2 years.

Water Quality Control

Prior to reorganization the standards of scientific control over the various functions varied considerably between authorities. Except for the largest authorities, standards generally were inadequate because of the limited number of qualified and experienced staff available. Reorganization has enabled these scientific workers to be used to better advantage by covering wider areas as well as becoming involved in the broader implications of the total water cycle.

An immediate effect was felt at the rural sewage works that had never before been supervised by a qualified staff. Brought under the control of supervisors from nearby larger works, the unsatisfactory effluents resulting from a lack of operational knowledge soon improved. Bizarre stories of the former period range from the sewage works discovered by using a scythe to the works where the operator grew vegetables on the sludge holding areas during the summer, preventing desludging of the settlement tanks. In general, the days of operatives who found new ways of not running sewage works are over with the coming of the new water authorities.

Similarly, the quality of water supplies has been given a high priority. One of the first steps taken by the new authorities has been to ensure that the consumer receives water that is bacteriologically safe. This has been achieved by ensuring that chlorination is undertaken properly and by frequent bacteriological testing of raw water, treated water and water supplied from the mains.

Bringing together sewage treatment and water supply functions under the same organization introduced the possibility of contamination. There has been considerable pressure to use personnel as widely as possible, a potential danger that is being overcome by restricting

Domestic land fill site lined with plastic sheeting to prevent drainage polluting ground-water resources. Liquid draining from the refuse is collected in a sump and pumped to a nearby sewage works for treatment.

water treatment and sewage works staffs to their own fields. Wherever staff can be used multifunctionally, such as in the case of electrical and mechanical engineers, a rigid code of practice has been introduced to avoid risks to water supplies.

Thus the reorganization has brought tighter control of water quality by ensuring that previously recommended safeguards are applied properly.

Water Research

Prior to reorganization there were four separate applied research centers concentrating on the water industry. Three of these disappeared and their research functions were taken over by the newly formed Water Research Centre which retained two of the three laboratories at Stevenage and Medmenham. Its governing body represents the interests, to a large extent, of the water authorities and the program of work previously underway has been reassessed to ensure it represents the new interests.

The Hydraulics Research Station at Wallingford, which comes under the Department of the Environment, continues to perform its traditional function: to predict the performance of hydraulic civil engineering works and to forecast their effect on the environment.

The Central Water Planning Unit and the Water Data Unit were also set up following the reorganization, both at Reading. The former provides a common service to the National Water Council, the water authorities and the government by reviewing the national and strategic aspects of water services planning. It will also study development of planning techniques. The latter comes under the umbrella of the Department of the Environment and provides advice on the type of information and data systems required for water management. It will also establish common standards and methods of data collection for the water authorities.

Similar reorganizations had to be made at the regional level. Within the authorities it was found that, while there was a multiplicity of small laboratories, each with limited capabilities, there was both a shortage of scientists with water industry experience and a severe limitation on the amount of advanced analysis that could be undertaken. My own water authority, in order to make the most of existing staff, set up a centralized divisional scientific service in Wessex with advanced analytical facilities.

In addition to the obvious advantages from pooling all scientific knowledge, the availability of a major laboratory makes possible regular analyses of samples for pesticides, trace metals and other pollutants which heretofore had been disturbing unknowns. An example of the benefits to be derived is the analysis of digested sewage sludge prior to recycling it onto the land. Previously, difficulty in determining the quantity of trace metals meant little control was possible in preventing the land application of sludge that might be toxic to farm crops. As a result, this means for disposal of sludge was falling into disrepute. Now, with a more detailed knowledge of sludge composition, it is possible to ensure that the farmland dosage is kept well below levels at which any impurities can affect crops.

Another outcome of centralizing facilities is the ability to introduce a high degree of automation to many of the analytical processes by reason of the large throughput of samples. A 12-channel autoanalyzer has been installed in the Wessex Water Authority's Saltford laboratory to measure the levels of ammonia, nitrite, nitrate, phosphate, chloride and silica present in samples; and its range is being extended to include other parameters.

Obvious advantages of automation are its ability to increase laboratory output, increase accuracy and reduce supporting administrative services. The Saltford laboratory is not only producing an automatic printout of the output from its analytical equipment, it also is designing that output for automatic feed through a terminal into a central computer where it can be stored

Fully equipped emergency vehicle can be called to site of any serious pollution occurring in Wessex Water Authority's jurisdiction.

Men of Wessex Water Authority install heavy duty oil boom on Bristol Avon River downstream of Bath, England.

Taking dissolved oxygen survey on lower reaches of the Bristol Avon River in England.

for rapid dissemination to similar terminals. There are two primary ways this analytical information is used: for immediate control by an operator at a specific works and for long term planning.

Other scientific studies made possible by centralizing facilities and staff include study of sea outfall sites using float and dye tracing, assessing the potential for extracting water from various rivers and monitoring the bacteriological quality of bathing beaches.

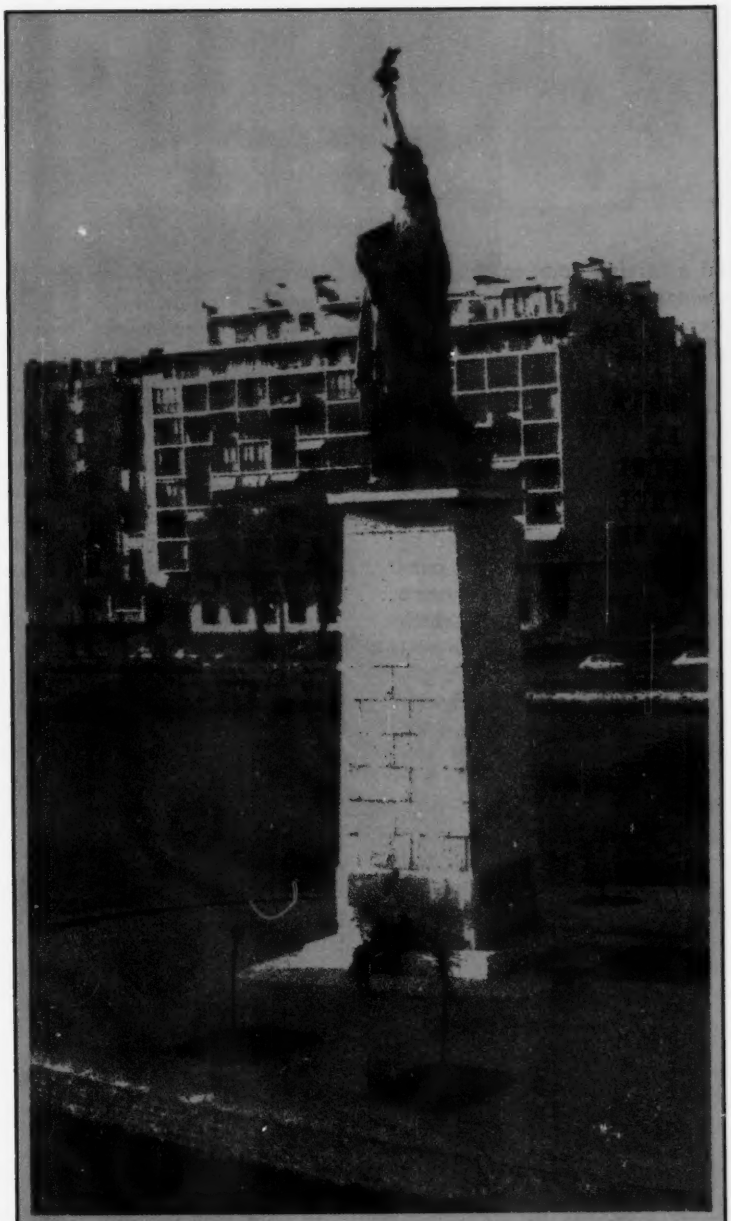
Regional Services

I will use my own authority as an example of what forms special regional services can take. The Wessex Water Authority has brought together a team of eight biologists to support the entire region. Besides collecting river bed samples, individual team members are studying eutrophication problems, the quality of fishing waters, controlling water weed growth and the effect of effluents on marine organisms.

River pollution inspectors, who previously policed the rivers, and trade effluent inspectors, all of whom have scientific backgrounds, have been brought together to make the most of their respective abilities. An important part of this work is dealing with emergencies reported by the public, which can range from the disposal of a bucketful of sewage from a recreation vehicle to the fracturing of a major cross country oil pipeline. Since the original information is so often incomplete, a major alert has to follow most complaints.

Wessex emergencies are routed to a 24-hour radio control center at Warminster which can contact standby staff after office hours and put into operation an emergency pollution drill. Emergency vehicles with pumps, oil booms and other equipment are available as is a team of divers. Had it not been for the reorganization of the former water services into regional authorities, the 24-hour coverage in Wessex would not have been possible. It was the bringing together of personnel from the various fields of water management, without any material increase in numbers, that made the 24-hour service practical.

It is too early to assess the overall benefits from the reorganized structure, which is still developing. However, the system the new structure is producing has a far more streamlined and efficient look than the one that existed prior to April 1, 1974. Unlike the multitude of fragmented authorities existing during the pre-1974 years, the regional water authorities now have the power to attack all forms of pollution with a more comprehensive program of controls. Although the improved coordination possible under this new corporate management structure already appears to be more effective, several more years will be necessary to complete the settling out process. Only then will we see the total benefits of such a drastic change in the United Kingdom's management of its water resources. Based on the benefits accrued as of April 1976, the prognostication looks good.■



Pollution Fees Are for Real in France

by Francois M. Fiessinger
and P. F. Teniere-Buchot

The year 1964 marked a turning point in the management of France's water quality problems. A new law passed in December of that year required the settling of water related problems through a consensus of all users within each of six hydrographic basins covering the entire country. It was the first step in combatting a widespread increase of water pollution that had been allowed to proliferate under the piecemeal legislation that existed prior to that time.

Up to that date, as was the case in many other countries, the use of water in France had been regulated by many separate laws, each implemented by various ministries. Underground water and industrial wastes came under the jurisdiction of the Ministry of Industry, which also served mines. The Ministry of Public Health was responsible for water supply, controlling the sanitary conditions and general health problems associated with that supply. Regulation of surface water was even more complicated. The rural waterways were under the jurisdiction of the Ministry of Agriculture, navigable waterways came under the Ministry of Public Works and everything concerning urban water problems, such as sanitation systems and sewage treatment plants, fell under the Ministry of the Interior. This division of responsibility produced the inevitable result: water pollution developed so rapidly after the Second World War that by the early sixties it had become a concern to the authorities as well as the general public.

The Law of 1964

Under the new law all those citizens within each basin who were concerned had to make joint decisions about which programs to set up and the financial means to implement them. The costs of providing each user with the quantity and quality of water needed had to be divided among all the users according to the benefit each derived and the disadvantages created for other users. This sharing of costs system created a strong incentive to neither waste nor pollute a resource which had become quite precious to all Frenchmen.

Two types of organizations were set up to implement the new law. The first type is the *basin committee*, composed of equal representation from among three categories:[1]

- national government representatives. These are delegates from the Ministries of Agriculture, Public Works, Industry, Interior, Public Health, Finances and Environment.
- local representatives. These are the mayors, county councilmen, presidents of trade associations.
- user representatives. These are the farmers, fishermen, water supply companies, industries, tourist agencies, etc.

The government representatives are appointed by the ministries, the local community representatives are elected by the county councils and the user delegates are appointed by the organizations they represent. Each committee elects its own president and vice president from among its nongovernment members and acts as a miniature parliament, since no program involving water resources can be financed without its vote of approval.

The second type of organization established by the 1964 law is the *basin agency*. This is the public administration organization that executes the committee decisions. Its financial autonomy makes it a powerful "water bank" in effect.

In addition to these new organizations, a *basin commission* of delegates from the various ministries was set up to coordinate on water problems of both national and local interest. In this way no ministerial department was deprived of any regulatory or judicial powers which could be used to support the economic measures taken by the basin agencies.

Agency Programs

Each of the agencies operates programs decided upon by their respective basin committees. These programs are normally of 4-year duration and have two basic objectives: developing water resources and fighting pollution.

Development of water resources includes traditional tasks such as the construction of dams, transfer of water from surplus to deficiency zones, conservation of ground water through recharge, control of land for future water needs, improvement of existing water supply networks and development of new ones.

It is the second objective, the *fight against pollution*, that has become the more important task. Communities within each agency's jurisdiction are provided with subsidies ranging from 20 to 40 percent of investment costs to build sanitation works. Additional government financial aid, which communities may borrow at low interest rates, reduces the actual cost to only 30 percent.

The basin agencies also give subsidies and loans to those industries which agree to spend money for their own treatment plants or to modify their manufacturing

Mr. Fiessinger is Chief of Research and Development for the Water and Lighting Company of Lyon. Mr. Teniere-Buchot is Chief of Technical Coordination and Regional Planning for the Seine-Normandy Basin's Financial Agency.

[1]*Committee numbers vary with each basin. The Seine-Normandy Basin Committee, for example, has 63 members.*

Parisian population and river traffic both contribute to pollution of Seine.

Members of Seine-Normandy Basin Committee serve as a miniature parliament, debating issues related to water pollution in their basin.

France organized itself into six major river basins in 1964 to improve its control over the nation's water quality.

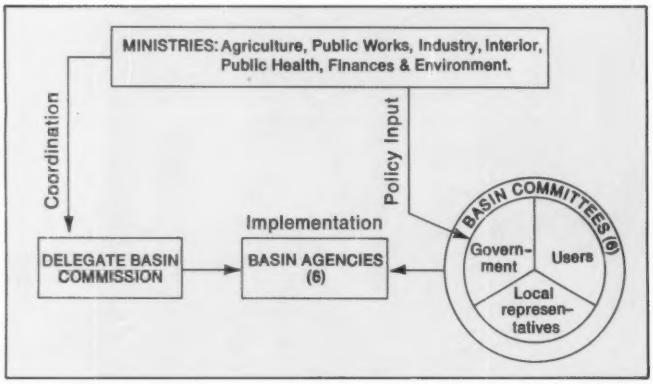
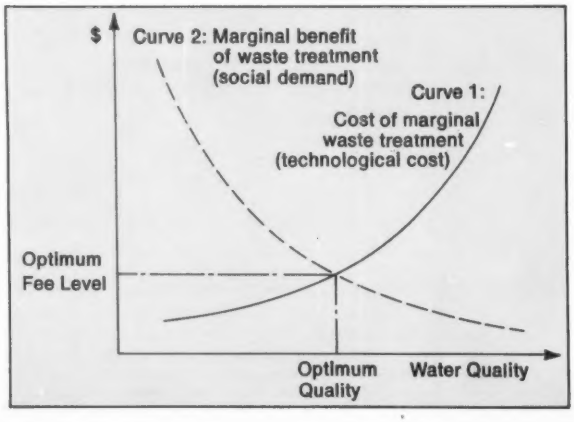


Diagram shows composition and relationship of the basin committees within the French national water pollution control system.

Figure 1. Intersection of opposing cost and benefit curves indicates theoretical cost of meeting public demand for clean water.



processes in order to save water. This form of assistance can vary from 40 to 80 percent of the cost, according to each industry's importance to the basin.

The means to support these subsidy programs come from a carefully calculated system of withdrawal and pollution fees. In essence, anyone who takes water out of the environment is required to pay for it, as well as anyone who pollutes. On the other hand, anyone who fights pollution, even his own, must be helped.

Pollution Fees

The idea of fees based upon the quantity of pollutants generated had been proposed for some time by economists, particularly the American Kneese.[2] In his study of the German system in the Ruhr basin, which has been in existence since 1914, he described the various economic measures a government may take to fight pollution.

These fall into two general categories. The first is taxation of each polluter according to the amount of pollution he discharges into the natural waters, so that he himself bears the cost of their purification. In the second category, which is collective rather than individual, the government subsidizes the antipollution measures from public funds.

In both cases, the amounts of fees collected (and subsidies paid) is determined by two opposing factors, both shown as opposing curves in figure 1. Curve 1 represents the cost of greater purification and curve 2 the willingness of the general public to support the improvement. What curve 1 is really saying is: the more one purifies, the more expensive it becomes. Curve 2 may be read as: the cleaner the rivers become, the greater the reluctance of the public to spend more to make them even cleaner.

Although curve 1 is not difficult to determine (through a knowledge of the antipollution equipment market), the values for curve 2 are still relatively unknown. There is, as yet, no accurate way of measuring public demand for water purification. Theoretical as it may be, figure 1 represents one of the objectives of the basin agencies: to express the public demand for clean water in economic terms. It does not, however, indicate which of the two economic methods should be used: fees or subsidies.

A partial answer to that question came from the Organization for Economic Cooperation and Development (OECD), composed of 24 western nations, in its formulation of the *Pollution-Pay Principle*, also referred to as *PPP*. All OECD members adopted this principle in 1974 under the philosophy that pollution fees create an incentive to curb pollution which subsidies do not. Therefore, no government money was to be given polluters, who were to bear the costs of reducing their own pollution through payment of fees, fines or a combination of both.

This solution has been adopted in France. However, these fees were not meant to replace the French

[2] *A. V. Kneese,* Strategies for Environmental Management *(Cambridge, Mass.: Harvard University Press, 1971).*

laws. Instead, they complement the laws by dealing with current pollution practices in an equitable fashion, regardless of whether these practices are illegal or are not yet covered by existing regulations.

Nonpoint Pollution

The determination of what fees to charge and the redistribution of the money collected in the form of subsidies is relatively simple in the case of point source pollutions. It becomes far more complex when dealing with nonpoint pollution sources. For practical purposes, a threshold of 250 *inhabitant-equivalent a day*[3] for pollution has been established for the collection of pollution fees. Similarly, a financial aid ceiling of 270 francs ($60) per *inhabitant-equivalent* has been set up for small sanitation works.

In practice, however, this system does not cover isolated dwellings, small enterprises not included in an urban grouping and a large number of farmers. Fees are particularly difficult to collect from the latter, who consider themselves guardians and protectors of nature and, therefore, are unwilling to support a fight against pollution which seems unrelated to their activities. Thus, the harm caused by fertilizers and pesticides—particularly to underground water—is unmitigated by the payment of fees. The only way in which these forms of pollution can be controlled is by the application of laws prohibiting use of the most harmful products, such as DDT, and the development of substitutes. These controls will be difficult to apply, for they will have to overcome the inertia of the farmers.

The problem of nonpoint domestic or industrial pollution seems minor by comparison. Domestic nonpoint pollution can be controlled by existing technology such as septic tanks and minisanitation (package treatment) plants. All we require is the necessary legal apparatus. As for the dwindling number of small workshops, their wastes are collected for treatment in large plants financed through fees paid by the major polluters. Thus the small workshops pay only a small part of the cost.

The Ideal Fee

Figure 1, unfortunately, indicates that the point of intersection representing an ideal fee for optimal water quality cannot be determined as long as we are unable to fix the values of curve 2.

We can, however, use the concept of an incentive fee. A fee that is totally incentive would be one which costs more to the polluter who does not treat his wastes, and therefore is operating illegally, than to the one who does. The former would have to pay a fee on all pollution, the latter only on the amount remaining after treatment—generally less than 20 percent—to compensate for the amortization and operating costs of his treatment plant.

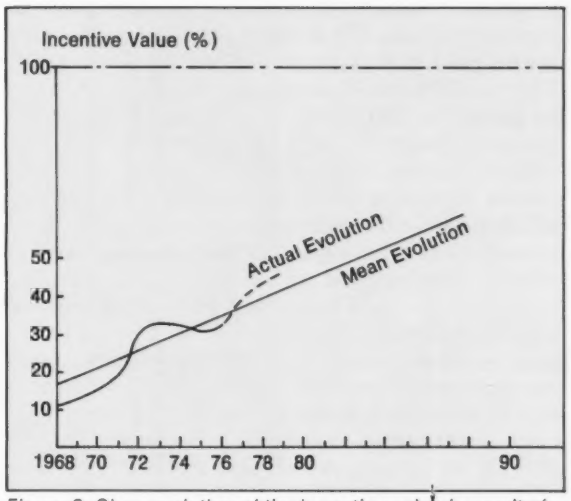


Figure 2. Slow evolution of the incentive value is result of French unwillingness to pay pollution fees at level high enough to provide the ideal in wastewater treatment.

For classical secondary treatment, a 1976 incentive fee should run approximately 20 francs ($4.50) per unit of inhabitant-equivalent. However, the user's unwillingness to pay has been a strong consideration, expressed through political pressure, in keeping fees down. The result is an actual 1976 fee of 7.75 francs ($1.70) per inhabitant-equivalent, merely 38 percent of the ideal. Figure 2 shows that incentive fees should reach about three-fourths of the ideal by 1990 and this gap will not disappear before the end of the century.

Future Directions

Application of the fee concept is evolving in three directions: widening of the bases upon which the fees are imposed, use of quality objectives and definition of long term goals.

Originally, to simplify measurement, the pollution fees were based only on the amounts of *suspended solids* and *oxidizable matter* released daily. This basis for measurement was established by taking an average day of the month in which maximum pollution occurred and then expressing the relationships in a simple mathematical formula. It permitted rapid creation of tables characterizing each type of pollution. Since they were established by agreement between the agencies and the polluters, the tables may be adjusted or replaced by either side at any time.

Two more criteria were added later. The amount of *soluble salts* was added in 1972 at a pollution fee rate of 1.350 francs ($0.31) per year. It is measured by a formula for the conductivity of soluble salts in water. *Toxicity* of the effluent was established in 1974, and is expressed as the number of equitox[4] per cubic meters per day. A fee of 0.8 franc ($0.175) a year is collected on each equitox-gram per day. It is probable that more

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[3] *An inhabitant-equivalent/day for pollution consists of combining separate inhabitant-equivalents for oxidizable matter and suspended solids, as in the following example:*

Inhabitant-equivalent for oxidizable matter $= \frac{COD + 2(BOD_5)}{3} = 57$

Inhabitant-equivalent for suspended solids $= 90$

Total for pollution 147 *grams/day*

[4] *An equitox equals a 50 percent death rate among a population of daphnia issued by parthenogenesis from the same individual. Daphnia is a minute freshwater crustacean related to the water flea.*

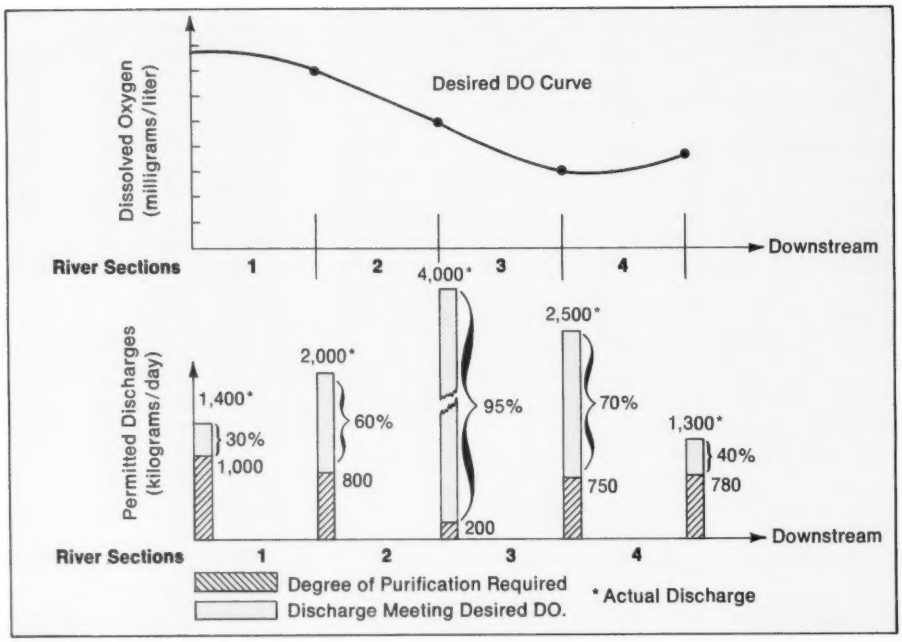

Figure 3. Quality objectives can be used to determine water policy by establishing desirable criteria for each section of a river.

Uses intended for each river within a basin determine the permissible levels of its principal water quality characteristics.

Use	Main Characteristics (permissible levels)		
All uses	Temperature DO BOD_5 COD	20°C 7 mg/l 3 mg/l 20 mg/l	(68°F)
Drinking water—after physico-chemical treatment Swimming and recreational	Temperature DO BOD_5 COD	20-22°C 5-7 mg/l 3-5 mg/l 20-25 mg/l	(68°-71.6°F)
Agriculture and industry Drinking water—only after advanced treatment (ozone, activated carbon . . .) Boating but no swimming Few fish	Temperature DO BOD_5 COD	22-25°C 3-5 mg/l 5-10 mg/l 25-40 mg/l	(71.6°-77°F)
Water transport Cooling Agriculture (irrigation)	Temperature DO BOD_5 COD	25-30°C 3 mg/l 10-25 mg/l 40-80 mg/l	(77°-86°F)
No use Minimum quality objective for rivers	Anaerobic conditions		

DO = dissolved oxygen
BOD_5 = 5-day biochemical oxygen demand
COD = chemical oxygen demand
mg/l = milligrams per liter

criteria will be added in the coming years, such as heat, nutrient, microbial and other types of discharges.

The second method uses objectives determined by the anticipated uses of different sections of a waterway, each of which requires different standards of quality. Figure 3 shows how these objectives can be used to determine water policy which, in turn, is reflected in the fees imposed on users. For example, by determining the desired levels of dissolved oxygen (DO) we can set the minimum levels and then calculate the maximum tolerable discharges that correlate to each DO level. Knowing the predicted discharges in each river section, we can evaluate the degree of purification necessary and its corresponding cost.

Feedback from the determination of these objectives is producing changes in the national law and adjust-

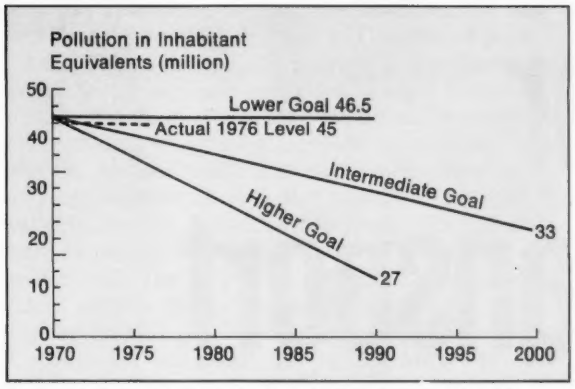

Figure 4. Present pollution load in France, roughly 45 million inhabitant equivalents, is not expected to reach the intermediate goal by 2000 without a 40 percent or greater increase in pollution fees.

ments at the local level. Eventually, this feedback will lead to creation of specific local fee levels which complement the financing of the pollution abatement program within the basin agency. The use of quality objectives creates a logical tie between the required quality for each effluent and the ultimate quality that the public expects to find in its river waters.

The third approach is to provide a general framework for the evolution of fees by incorporating local quality objectives into a wider, long term national plan. In 1970, two hypotheses were formulated on the abatement of pollution. The first advocated control of pollution at its existing level. The second proposed that the existing pollution be reduced 80 percent by 1990, which would mean all effluents would have to undergo secondary treatment. An intermediate solution was finally chosen that would meet the latter objective by the year 2000.

Figure 4 shows the present pollution load at roughly 45 million inhabitant equivalents. This means that to date only the lower, or 1970, goal has been met. In light of the financial commitment made for the next five years, this stability probably will be maintained until 1981. Therefore, the pollution fees will have to be increased by at least 40 percent to realize the intermediate goal of a pollution load lower than 33 million inhabitant equivalents by the turn of the century.

Reality Or Myth

Pollution fees are undoubtedly the most realistic part of any comprehensive water quality management plan. The very modesty of the goals and the uncertainty of achieving them—which some consider a weakness of a fee-based water policy—merely emphasize the difficulties that countries with liberal economies are facing in their fight against pollution. We feel that the collection of fees, neither too light nor too heavy, is a necessary complement to the existing laws on the use and discharge of water which, until recent years, had failed to win this fight in France.

The facts speak for themselves. It is now 8 years since the financially autonomous basin agencies began to collect fees for industrial and urban pollution in 1968. Prior to 1968, only 2,500 sewage treatment plants, very unequal in efficiency, had been created under the existing regulations. From 1968 to 1973 alone, construction of more than 2,000 new plants has been financed through these fees. Although river pollution has not yet decreased, it has reached a stationary level with the current rate of eight new plants a week being put into operation. The anti-pollution equipment market is developing rapidly in conjunction with this growth. This market will pass the 1.5 billion francs ($330 million) mark in 1976.

It does not follow however, as is commonly thought, that the countries which have chosen a policy of water control based on pollution fees have thereby neglected their regulatory controls.[5] Economic measures to combat water pollution complement rather than replace legal controls. This was not apparent at the time the new basin agencies were created. At that time they were greeted less than enthusiastically. Some saw them as an attempt to increase the power of the government, others feared that the pollution fees would rapidly become "permits to pollute." These attitudes changed rapidly after 1968, when the basin agencies started to function with a budget derived from government loans of 60 million francs ($13 million) which they totally repaid in less than 4 years. In contrast, without any government assistance, the combined 1976 budgets of the six agencies will reach 1 billion francs ($225 million). Two-thirds will come from pollution fees, the remaining third from withdrawal fees.

This 42 percent annual increase (actually only 30 percent if one takes inflation into account) is an indicator of growing importance—it is mainly due to acceptance of the agencies by those who pay the fees. The users, because they are directly involved in the functioning of the agencies—through participation in the basin committees—have a sense of solidarity that motivates them to pay the fees which will finance those activities they have decided upon for themselves.

Direct participation of the users in formulating water policy is a characteristic common to other European organizations that resemble the French basin agencies. We see it in Germany's *Ruhrverband* and *Ruhrtalsspererenverein*, in the Netherlands' *waterschappen* and in the United Kingdom's *regional water authorities*.[6]

In all these cases, users have direct control over the money paid in fees and can thus measure the benefits of their own financial participation. Pollution fees represent the reality behind the improvement of water quality in France. Without such fees, the case for water quality management would be a myth. ■

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[5] *Besides France, those countries using pollution fees include the Netherlands and Hungary and, to a lesser extent, Germany, Denmark and the United Kingdom.*

[6] *See article starting on page 23.*

Designing for Sediment Transport

Stream channelization is one of several responses to local flooding problems whenever a structural type of solution appears necessary. In selecting this form of manmade modification, the decision makers should be aware of the extent to which the stream's natural balance will be disturbed.

By **Walter M. Linder**
Chief Hydrologist
Kansas City District

Much of the effort spent planning and designing channel modifications dwells heavily on how much water must be considered and then what to do with it. An equally important, but often neglected, aspect is the sediment transported by the water. Failure to consider sediment transport characteristics for a given stream can lead to a situation in which a manmade modification will have to be periodically repaired. Once disturbed, a stream begins an automatic and relentless process that culminates in its reaching a new state of equilibrium with nature. The new equilibrium may or may not have characteristics similar to the stream's original state.

In the past, too many problems associated with flood control, drainage, navigation and other types of water resource projects have been handled by modifying the river channels involved without giving equal thought to the sediment being transported by the water flowing in those channels. Misunderstanding the role of water in transporting enormous quantities of sediment has been more a matter of neglect than unawareness.

Failure to comprehend or consider the processes by which sediment is transported has led to many errors in the planning and design of channel modification projects. These processes, in turn, are influenced by the amount and size of the sediment being transported.

The amount of sediment moved by a stream can vary from almost nothing to a flow that is more solids than liquid; visualize a flash flood roaring down a normally dry desert wash. Particularly prone to transporting enormous quantities of sediment over a period of time are those streams that flow through alluvial deposits or drain watersheds with highly erodible soils.

This river in western Iowa was straightened shortly after World War I. It is now in the process of flattening its slope by meandering, causing severe erosion on outside of bends.

Early day references, for example, described the Missouri River as too thick to drink and too thin to plow.

According to its size, the material is transported by two distinctly separate processes. Larger particles—cobbles, gravels, coarse sands—are normally moved by rolling, sliding or jumping along the streambed. They form the *bedload* which a stream can transport to its carrying capacity if sufficient movable material is available. Smaller particles—fine sands, silts and clays—are carried in continuous suspension, forming a *suspended load*. The volume of suspended load can vary widely as it is chiefly dependent upon what is supplied by runoff from the drainage area. Channel characteristics are influenced less by the suspended load than by the larger particles forming the bedload, although the suspended load can also have a significant effect on some streams.

In the process of transporting its sediment load, a stream is always trying to reach an equilibrium condition. This means that a stream adjusts its slope and, to a certain extent, its channel dimensions so that with the available discharge, it will provide just the velocity required to transport the sediment load furnished by the drainage basin. This does not imply that a stream provides a slope and channel dimension that will carry all flows and their associated sediment loads. Instead, its characteristics reflect a discharge that if constant would transport just the total volume of sediment available over a period of time such as one year. The term commonly applied to this quantity of flow is *dominant discharge*.

The final channel configuration and the rate at which adjustment to a new equilibrium occurs is dependent upon the material in the bed and banks of the stream. Sediment that is fine grained and cohesionless will be highly erodible and the stream's readjustment will be relatively rapid, with a channel that tends to be wide and shallow. Where cohesive clays predominate, there will be more resistance to erosion and changes will be slower, with a channel that tends to be deep and narrow.

Movement of sediment is a major geomorphic process in the slow but constant leveling of the earth's surface. Weathering—by physical, chemical and biological means—is endlessly breaking down the parent rock on the earth's surface into smaller particles. Runoff from melting ice and snow and rainfall, in the form of both sheet flow and streamflow, continuously transports the weathered particles to a lower elevation. The

Vegetation starts to grow once surface of the deposits remains above water for any significant period of time.

Low flow channel develops through newly formed sediment deposits in an enlarged trapezoidal shaped channel.

Material in this well armored alluvial fan stream bed is being measured within the outlined sample pit. Armor layer has been removed to expose the underlying fine grained material.

mechanics of sediment transport still are not fully understood, and attempts to predict the transport rate and the resulting amount of erosion and deposition can be only estimates.

When it becomes apparent that something must be done to prevent flood damage at a specific location, enlarging and straightening the stream channel are usually the first techniques to be proposed. These appear to be logical approaches as they provide, respectively, a greater cross-sectional area for the flow and a steeper slope to increase the velocity. Unfortunately, enlarging and straightening produce major changes in stream characteristics and, if carried out, the altered stream reacts by attempting to restore a state of equilibrium within its new banks. In the process of readjusting to a new equilibrium, a number of effects, both short and long term, can occur that will have a significant impact upon man's efforts to achieve flood control.

There are numerous examples where streams were straightened many years ago for the purpose of improving drainage and reducing flood damages. In many instances, those objectives have been adequately met. Unfortunately, there have been adverse effects in others. This is particularly true where the work was carried out over long reaches and the material through which the stream flowed was highly erodible. Streams that were once gently meandering, 10 to 12 feet deep and a few tens of feet wide, are now 20 to 30 feet deep and several hundred feet wide. Many acres of fertile farmland have been lost as the streams widened and deepened and degradation extended up the tributaries. Bridges continue to be damaged or destroyed during every major runoff. Millions of tons of sediment have been prematurely deposited in downstream areas. Downstream flood heights have increased because the natural valley no longer acts as a reservoir, slowing the movement rate of floodwaters.

Eventually the stream that has been straightened will develop new meanders as it resumes attempts to flatten its slope. This creates further erosion and sedimentation damage as each successive period of high flow will generate renewed erosion along the outside of every new bend. All of this occurs because the action of straightening the stream channel has increased the stream's capacity for transporting sediment.

Less dramatic but still serious effects can occur after less extensive channel modifications. Let us take for an illustration a flood control technique used frequently in highly developed areas. This is the practice of enlarging a channel throughout the problem area to provide the desired discharge capacity. This technique is satisfactory for a short period of time. As the flow enters the enlarged section, however, its velocity is reduced, thus decreasing the stream's capacity to transport sediment. As a result, all or part of the sediment load entering the enlarged sections of channel is deposited along the banks. Eventually, the stream develops a channel through the more recent deposits that approximates its original dimensions. Development of vegetation on top of the deposits further retards the flow, creating additional deposition. Low berms form rapidly after a small number of high flows. As the height of the deposits increase, the rate of deposition slows. Still, a significant loss of discharge capacity occurs within a short period of time.

Ultimately, the surface of the deposits will approach the original ground level and the stream will have restored its former channel characteristics. Either a progressive loss in flood control capacity must be accepted or a very high maintenance cost must be sustained to periodically remove the sediment deposits.

Another problem resulting from channel enlargement is acceleration of upstream erosion. For any given discharge, water depth in the enlarged channel will be less than in the natural channel just upstream. This creates a steepened water surface slope, or *drawdown*, with increased flow velocities in the natural channel for some distance upstream of the enlarged reach. If erodible soils are present, severe bank erosion and bed degradation will occur, often undermining or outflanking structures that are located within the drawdown reach. This erosion also enlarges the natural channel causing the drawdown to move progressively upstream. Erosion of this type eventually can extend for miles upstream of even a relatively short reach of enlarged channel. This process also provides a major source of sediment for deposition in the enlarged channel.

Special problems can result from channel modifications in semiarid and mountainous areas. Urban development here frequently takes place at the base of mountains on the alluvial fans which have been deposited where streams exit from the mountains into major river valleys or intermountain basins. Streams flowing through these fans usually are quite shallow and floodflows spread in a thin sheet over the surface of the fan whenever the channel capacity is exceeded. Since the slopes and velocities of streams on alluvial fans are relatively high, their ability to transport bed material is also high.

The deposits in alluvial fans normally range in size from cobbles to fine sands. In the process of developing a channel through the deposits, the streamflow sorts the material and removes the finer particles. The larger and heavier cobbles, which cannot be transported so easily, remain as a protective layer on the surface of the stream bed. Beneath this *armor layer*, usually no more than one grain or cobble diameter in thickness, is the normal distribution of grain sizes found throughout the alluvial deposits.

Any mechanical enlargement of the channel to increase its capacity will remove the armor layer and expose the underlying stream bed to erosion. Until sufficient coarse material accumulates on the bed surface to form a new armor layer, the finer particles will again be washed away. If the percentage of coarse material in the mixture is small, a substantial amount of channel enlargement and degradation must take place before a new armor layer can develop.

Lack of grade control in a high flow diversion channel results in severe head cutting.

Although many adverse effects have resulted from disturbing the equilibrium of streams, that does not imply that all flood control works involving channel modifications must eventually fail. The implication, instead, is that techniques should be employed that consider sediment transport characteristics and stream equilibrium. By so doing, the reactions of a stream to manmade changes can be minimized.

One technique, suggested by the formation of sediment deposits within an enlarged channel, uses a composite channel geometry in which the existing channel is enlarged very little, if any. At some intermediate elevation between the stream bed and the top of the bank, a high flow berm can be excavated on one or both sides of the channel. The undisturbed portion of the channel cross section provides for the transport of sediment during normal flows and the more frequent minor floods. During periods of major floods, the berm provides additional flow area. Care must be exercised to avoid placing the high flow berm at too low an elevation. Otherwise, the berm is inundated too frequently, remains wet, aggrades rapidly, and becomes extremely difficult to maintain.

The adverse environmental impact which accompanies a channel modification can also be reduced by use of composite channel designs. For example, excavating the high flow berm on only one side of the stream will leave the trees, vegetation and other physical features on the opposite side undisturbed. High flow cutoff channels can be constructed across meander loops, thus preserving portions of a stream's natural meanders. This technique, however, requires careful design and the use of some form of control structure at the point where the high flow channel rejoins the natural channel alignment at the downstream end of the loop. Otherwise, erosion can occur in the high flow channel during a flood, with the strong possibility that this cutoff will capture all of the flow. An environmental advantage of composite channels is that if the berms are not inundated too frequently, limited plantings of trees and selected shrubbery may be used to form a green belt or park area.

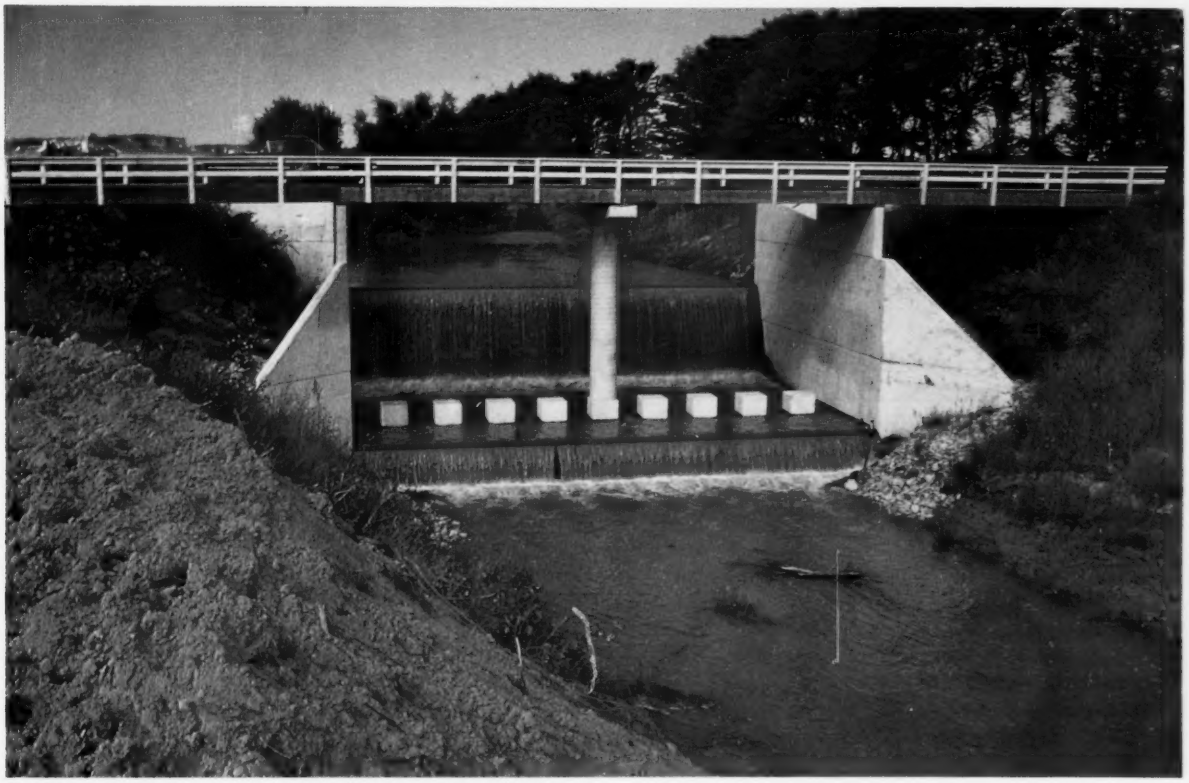
When the stream is of the type where a natural armor layer is present, the armor layer must be replaced after any modification. If the stream's capacity to transport bedload is increased, the replacement layer must consist of larger material than that originally present on the stream bed.

The negative side of selecting a composite channel is that this design does not offer a hydraulically efficient cross section because it exposes a large friction surface in relation to the flow area. Thus, the composite channel requires a greater right-of-way width than does the more conventional trapezoidal cross section normally used for channel enlargements. However, it still represents a good compromise design when considering reduction of flood damages, sediment transport and minimization of environmental damage.

Another alternative is extensive use of levees. Levees used without any accompanying channel modification can effectively control flooding with little or no impact on sediment transport characteristics. Where sufficient width is available along the stream, levees can be set back some reasonable distance to provide a floodway for discharges in excess of channel capacity. If no work is done on the channel, except for removal of major obstructions to the flow, the channel can remain essentially in its natural state. In this way, environmental damage can be minimized and sediment transport characteristics maintained. If space is limited, a combination of berms or high flow channels and levees may be possible.

Some disadvantages do result from using levees. Removal of buildings and costly relocations of utilities and highway and railroad crossings are often necessary. Where levees create a significant reduction in the width

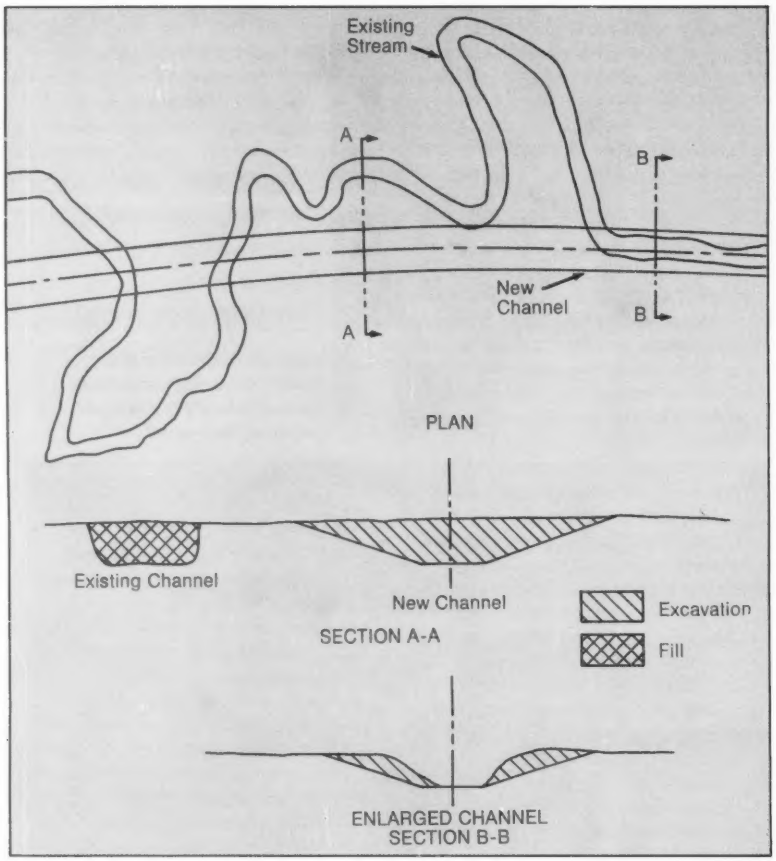
Composite channel design provides a smaller central channel for normal flow. Wide berms with adjacent levees prevent flooding of valuable farmland.

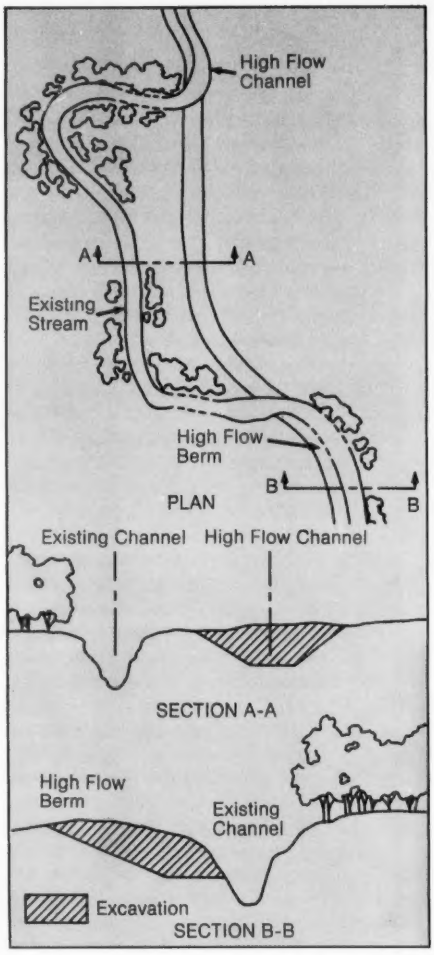


Concrete structure controls a large drop in water surface elevation. Stilling basin at base of drop dissipates energy of the falling water and prevents erosion downstream of the structure.

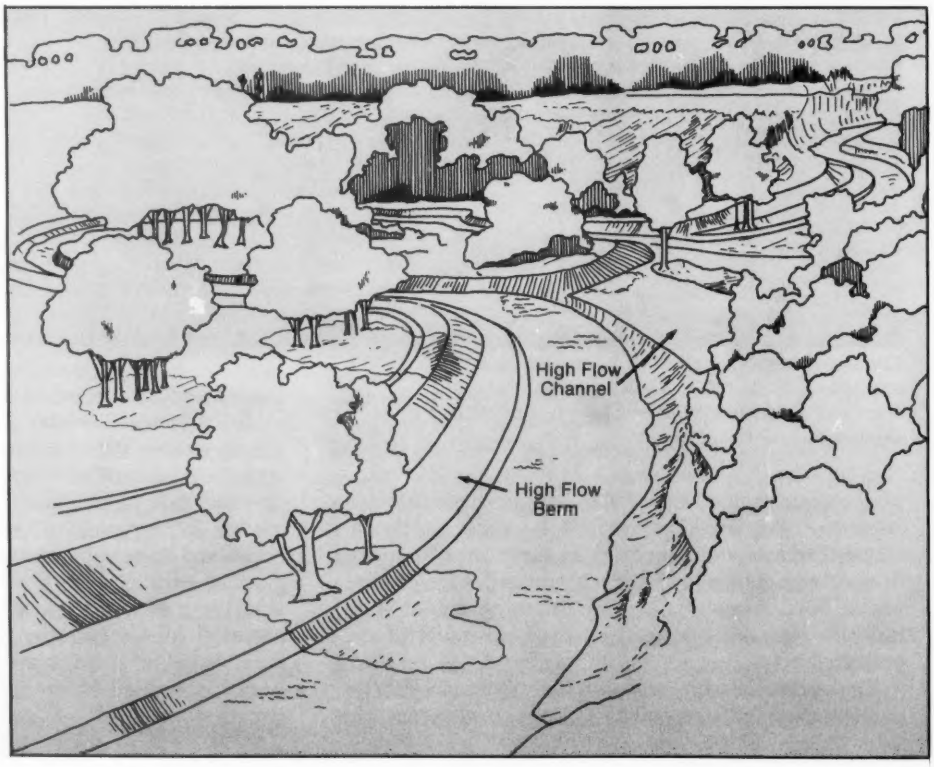
of the natural floodway, water surface elevations upstream of the leveed reach will be substantially increased over natural conditions in the event of a major flood. As might be imagined, the potential for causing higher flood levels often elicits strong objections from residents and other property owners upstream of the protected area.

The potential for uncontrolled erosion due to straightening and steepening the slope of a stream can be reduced by the use of grade control structures designed to lower the water surface in one or more steps. In this manner the excess energy of the flow can be dissipated at controlled locations. Bank and bed protection can then be provided at these locations to prevent erosion in the vicinity of each structure. The increased depth and flattened water surface slope upstream of a grade control structure combine to reduce the flow velocity to nonerosive levels. This, in turn, reduces the potential for uncontrolled erosion and excessive sediment loads at downstream locations which otherwise would be caused by straightening and steepening the stream slope.





Above profile of traditional design shows a channel enlarged by straightening its meanders. Channel modification is less extensive in composite design, above right, where high flow berm and high flow channel preserve portions of the stream's natural meanders. Perspective drawing at right shows a project using composite channel geometry to minimize adverse environmental effects.



Gabions (rock filled wire baskets) are used here to form series of small steps in bed elevation and also to stabilize base of side slope.

Often it is possible to design low elevation structures that exert their major influence on normal flows and the more frequent minor floods. This is desirable because flows of these lesser magnitudes exist the vast majority of the time and account for a major portion of the erosion due to steepening of the water slope. High flows will pass over these low structures with only a minimum increase in water surface elevations upstream of the structures. If the erosion that would occur during the infrequent high flows is unacceptable, it can be prevented by the use of bank protection such as riprap. In many cases, a compromise between grade control for normal flows and bank protection in critical areas will be the most economical solution.

Grade control structures may be built of various materials, such as concrete for larger and higher structures, and quarried rock and sheet piling for the lower and smaller structures. Rock filled wire baskets called *gabions* have been utilized in the construction of weirs and low dams in Europe for many years. Gabions are being used more frequently in the United States as additional experience with their performance is gained. Quarried rock, alone or in combination with sheet piling, is one of the most economical structures to build where rock of sufficient size and durability is available. Rock structures must be limited to situations where they will permit the free overfall of low flows only and will be completely submerged during high flows. My observation has been that when free overfall velocities exceed about 10 to 12 feet per second over a rock structure, the size of rock required for stability becomes too large for practical use.

In addition to the numerous proven designs now available for the construction of grade control structures, new concepts for better performance and more economical design are continuously being tested in hydraulic laboratories such as the Waterways Experiment Station operated by the Corps of Engineers at Vicksburg, Miss.

Channel modification should not be condemned as a technique for flood control, for in many cases the straightening of a stream has proved to be an adequate response.

We must be aware, however, that all streams have and always will transport sediment and, in the process, establish a form of equilibrium with nature. Over the years, certain techniques have been developed which can minimize both the environmental impacts and the disturbance to a stream's equilibrium caused by flood control measures.

Designs that take these factors into consideration are expensive to execute and are frequently rejected for that reason. Unfortunately, the ultimate cost of the uncontrolled erosion and excessive downstream sediment deposition that follow traditional channel modification is often far greater than the initial cost of a design that recognizes the influence of sediment transport characteristics on a stream's state of equilibrium.■

Events, Deeds & Deliberations

A Wave Maker Debuts

The first wave tank built inside the new Jay V. Hall Jr. Laboratory at the Coastal Engineering Research Center (CERC) went on line in early February. It will be followed by three other wave tanks of varying sizes at the $5.5-million laboratory dedicated last August by the U.S. Army Corps of Engineers at Fort Belvoir, Va.

The new tank measures 1.5 feet wide, 3 feet deep and 150 feet long. Not yet on line, the other wave tanks are physically complete, but require further adjustments. Two of these are inside the laboratory and measure, respectively, 3 feet wide by 3 feet deep by 150 feet long and 15 feet wide by 4 feet deep by 140 feet long. All three of the flume-shaped indoor tanks will be used to study the effects of ocean waves and tides on models of shore protection devices. Results of these tests will be translated to a larger scale in the outdoor tank, which is 15 feet wide by 20 feet deep by 635 feet long. The large outside tank will be capable of generating waves 6 feet high.

Also a part of the new laboratory is an indoor test basin that is 300 feet wide by 4 feet deep by 150 feet long. A wave generating machine connected to the basin will create conditions simulating the movement of sedimentation along a shoreline modeled out of sand.

These general purpose tanks and the test basin replace less sophisticated facilities left behind by CERC when it moved from the Dalecarlia Reservoir area in Washington, D.C. to Fort Belvoir. ■

Deauthorization of Corps Projects

Assistant Secretary of the Army Victor V. Veysey on March 16, 1976 recommended that Congress deauthorize 52 U.S. Army Corps of Engineers water resources projects in 21 States.

This recommendation was submitted in accordance with Section 12 of the Water Resources Development Act of 1974. Section 12 requires that the Secretary of the Army, acting through the Chief of Engineers, at least annually review and submit to Congress a list of water resources projects which he determines should no longer be authorized. Listed projects are those having been authorized for at least 8 years but not funded during the past 8 years.

Before deauthorization is recommended to Congress, Federal agencies as well as Governors of affected States must be allowed 60 days to review and comment on the proposal. These views, along with the Army's reasons for recommending deauthorization of each project, must accompany the annual report to Congress.

Projects which come within any of the following five categories can be recommended for deauthorization:

- lack of economic justification
- not adequate to meet current or prospective needs and obtaining adequate improvement would require additional funding authorization from Congress
- significant and unacceptable adverse environmental impacts
- general opposition or lack of cooperation from local interests
- part or all of the project has been accomplished by other means or is no longer required.

With this latest recommendation, the Corps of Engineers has now proposed deauthorization of nearly half of its approximately 800 projects eligible under Section 12. The Corps is currently reviewing an additional 100 projects for possible inclusion in next year's report. ■

Chief of Engineers Makes Locks & Dam 26 Proposal

The Chief of Engineers announced his proposal to recommend a single lock measuring 1,200 feet long by 110 feet wide to replace the two deteriorating chambers at the existing Locks and Dam 26 on the upper Mississippi River. On March 15, Lt. Gen. W. C. Gribble, Jr. proposed that the new dam and its lock be located about 2 miles downstream from the existing structure near Alton, Ill. Estimated cost, based on January 1976 prices, would be $390 million.

Design of the proposed single-lock structure would include a provision for adding a second lock at a future time if Congress authorizes such an addition. Economic and environmental studies would be undertaken, meanwhile, to identify the best size and specific environmental impacts of a second lock. An orderly, phased construction program could proceed for about 4 years before a decision would be required on another lock.

After comments are received from all concerned Governors and Federal agencies, the Chief of Engineers' recommendation will be sent to the Secretary of the Army, who will coordinate with the Office of Management and Budget before submitting his report to Congress. ■

New Hydrologic Maps

A new series of nationally consistent State Hydrologic Unit Maps is being prepared by the U.S. Geological Survey in cooperation with the U.S. Water Resources

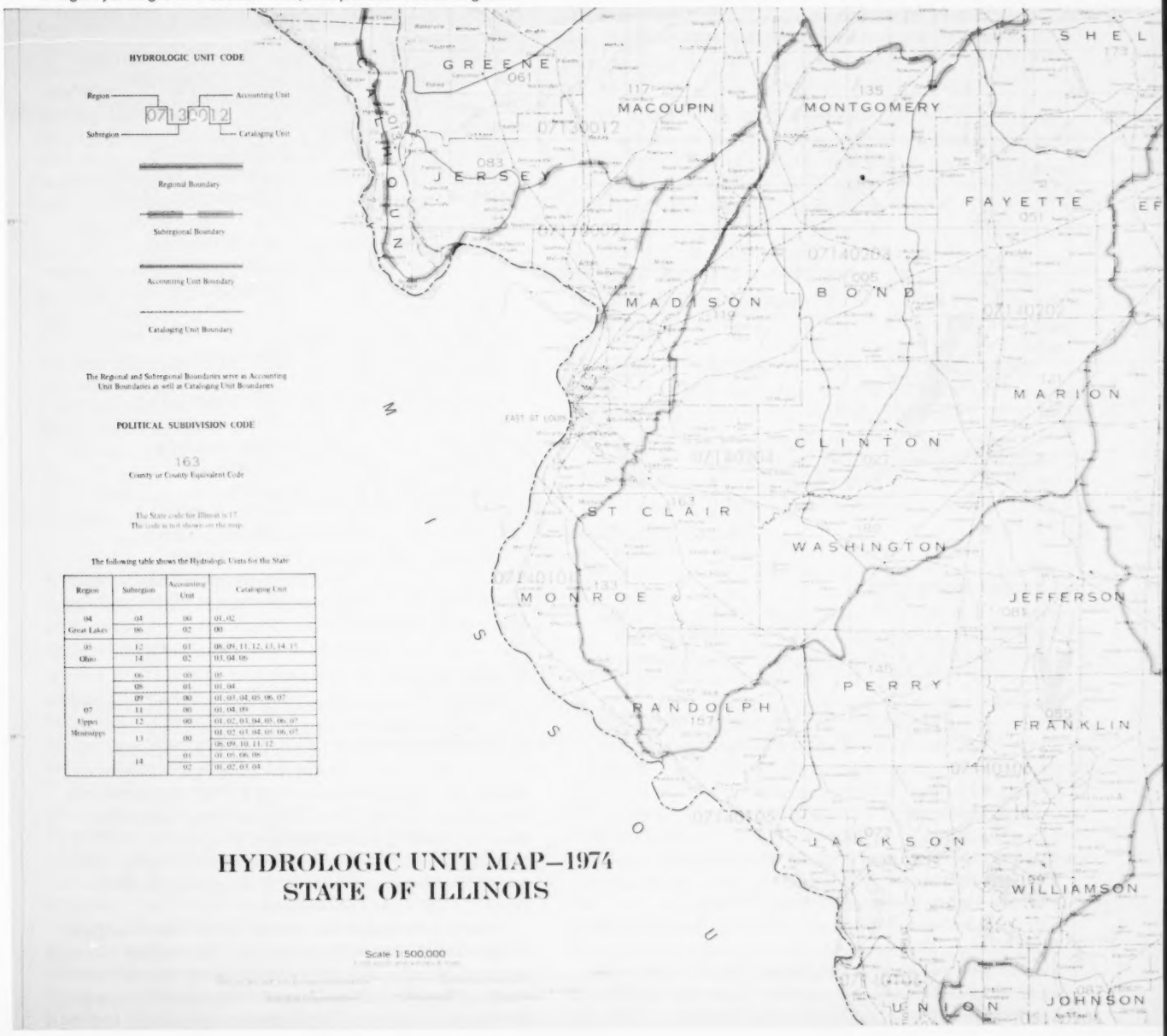
Council. These maps have been reviewed and agreed upon by virtually every Federal and State water resources agency in the country. Maps of 35 States are already available with the remainder scheduled to be published by September 30, 1976.

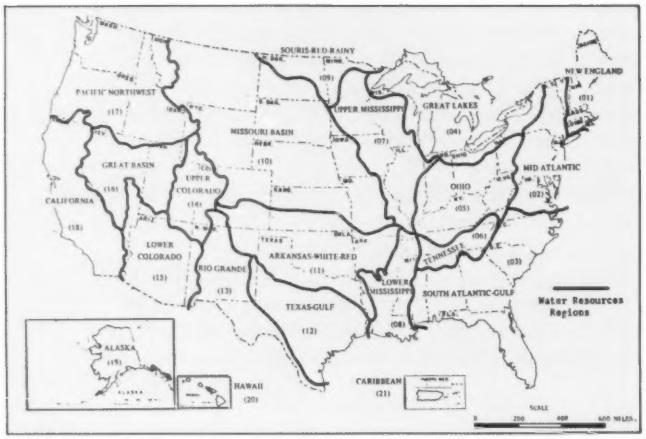
Using the U.S. Geological Survey State base map series, the new maps present twice the detail of previous hydrologic unit maps at a scale of 1:500,000, or 1 inch equals nearly 8 miles. They delineate every river basin in the United States having a drainage area averaging at least 700 square miles.

The four-color maps assign a distinct computer code to each river basin and provide information on drainage, culture, hydrography and hydrologic boundaries for each of the 21 regions and 222 subregions designated by the Water Resources Council. They also depict the boundaries and codes of the 345 accounting units within the National Water Data Network and the 2,100 cataloging units of the Geological Survey's "Catalog of Information on Water Data." The regions, subregions and accounting units are aggregates of the basic cataloging units in an ascending hierarchy.

The project was initiated by the U.S. Geological Survey's Office of Water Data Coordination in the fall of 1972 and has resulted in a standard geographical framework for more detailed water and related land resource

Part of a typical State Hydrologic Unit Map shows culture in black, hydrography in blue, hydrologic unit boundaries and 8-digit hydrologic unit codes in red, and political codes in green.





Map shows the distinct code number of each water resource region in the United States.

planning. Prior to publication of these maps, water resources planners had been using a variety of criteria for the naming, coding and delineating of hydrologic boundaries. The thorough review process that the new map series has undergone should eliminate the disagreements among water resources agencies at all levels of government, disagreements which arose from the lack of uniformity on the maps previously available. Use of the new series will aid in the organization and dissemination of data as well as in providing a consistent starting point for water resources planners.

Copies of the State Hydrologic Unit Maps for States east of the Mississippi River can be purchased by mail from the Branch of Distribution, Geological Survey, 1200 South Eads Street, Arlington, Virginia 22202. Maps of States west of the Mississippi River can be obtained by writing to the Distribution Section, Geological Survey, Federal Center, Denver, Colorado 80225. ■

Changes of Command

Major General J. W. Morris was elevated to U.S. Army Chief of Engineers on July 1, 1976. Formerly deputy chief of engineers, General Morris succeeded Lieutenant General W. C. Gribble, Jr., who retired after serving in the Corps' top position for nearly 3 years.

Among the posts General Gribble had held during his 35 years of service were those of Chief of Research and Development and principal advisor to the Army Chief of Staff on all military engineering matters.

Brigadier General Norman G. Delbridge, Jr. became European Division Engineer in May, with headquarters at Frankfurt, Germany. Brigadier General Delbridge formerly was commander of the Division Support Command of the 3rd Armored Division in Germany.

Brigadier General William E. Read became Missouri River Division Engineer in June, with headquarters at Omaha. Prior to his new assignment, Brigadier General Read served as deputy commanding general of the U.S. Army Aviation Systems Command at St. Louis.

Former Deputy Director of Civil Works Brigadier General Kenneth E. McIntyre was named South Atlantic Division Engineer, with headquarters at Atlanta. His assignment was effective on June 15.

On the same date Brigadier General Drake Wilson took his place as new deputy director of Civil Works. Brigadier General Wilson was formerly Mobile District Engineer.

Colonel John L. Cannon was named director of the Army Engineer Waterways Experiment Station at Vicksburg, Miss., effective June 14. As the principal research, testing and development facility of the Corps, the Waterways Experiment Station engages in research and engineering investigations in the fields of hydraulics, soil and rock mechanics, concrete, mobility of military vehicles, weapons effects, pavements, environmental relationships, aquatic weeds, water quality and dredged material research.

Several new district engineer assignments also have been announced in recent months. The new district engineers, their headquarters and the effective months of their assignments follow:

Col. Forrest T. Gay, III, St. Paul, January
Col. Harvey L. Arnold, Jr., Portland, February
Col. Richard E. Leonard, Albuquerque, March
Col. Andrew C. Remson, Jr., Chicago, April
Col. Francis J. Walter, Jr., Savannah, May
Col. Jon C. Vanden Bosch, Galveston, May
Col. Hugh Robinson, Los Angeles, May
Col. Robert W. Lockridge, Jr., Memphis, June
Col. Christopher J. Allaire, Walla Walla, June
Col. Charlie L. Blalock, Mobile, June
Col. George R. Robertson, Anchorage, June
Col. George K. Withers, Jr., Baltimore, July
Col. Daniel D. Ludwig, Buffalo, July
Col. Donald M. O'Shei, Sacramento, July
Col. Leon E. McKinney, St. Louis, July
Col. James W. Ray, Omaha, July
Col. John A. Poteat, Jr., Seattle, August
Col. John F. Wall, Jr., Fort Worth, August
Col. Melvyn D. Remus, Detroit, August

Colonel John P. Chandler was named New England Division Engineer with headquarters at Waltham, Mass., effective in August. ■

A Silver Anvil

The story of how the *Sergeant Floyd,* an old Corps towboat, came to make its current 18-month Bicentennial voyage brought the U.S. Army Corps of Engineers the coveted Silver Anvil Award from the Public Relations Society of America at the society's 32nd annual awards banquet in Chicago. The Corps entry was judged the most outstanding public relations program for 1975 in the Institutional Programs-Government category, and one of the 25 winners selected from among the 295 entries in the annual competition.

Basis for the award was the use of the 200th birthday of the Army Corps of Engineers (1975) and the national Bicentennial (1976) as a timely vehicle for carrying the story of the Corps' 200 years of service to the American people. This theme was physically imple-

mented by converting a towboat on the verge of being decommissioned into a floating museum. Exhibits on the vessel include visitor-activated audio-visual shows recounting the early history of our country and the related role of the Corps of Engineers in America's development. Illustrations cover Corps efforts in flood damage prevention, hydropower generation, recreation, civil disaster work, environmental undertakings and major engineering feats. (See page 46 of the Fall 1975 issue for a photo story of the *Sergeant Floyd*.)

Launched on June 17, 1975, the *Sergeant Floyd* has covered over 10,000 miles of inland and Gulf Intracoastal waterways since its voyage began at St. Louis in June 1975 and has visited over 140 communities. More than 1 million people are expected to view this floating museum before its voyage ends on December 31, 1976. Persons along the inland waterways interested in seeing this museum may contact their nearest Corps of Engineers district office to find out which cities remain on the vessel's itinerary.

The vessel was named for Sergeant Charles Floyd, an Army Engineer who accompanied Lewis and Clark in their 1803 exploration of the newly acquired Louisiana Territory. ■

A New Inland Waterways Map

A new black and white map showing the principal inland waterways of the Gulf Coast States and the Mississippi River basin has been published by the U.S. Army Corps of Engineers. Available in sizes 32 by 44 inches, 17 by 34 inches and 8 by 10½ inches, the map delineates the 18,800 miles of major waterways that are in operation, under construction, or are authorized for development in coming years.

The new waterways map can be obtained free of charge by contacting the Public Affairs Office of the Lower Mississippi Valley Division in Vicksburg, the Missouri River Division in Omaha, the North Central Division in Chicago, the South Atlantic Division in Atlanta or the Southwestern Division in Dallas.

Corps district Public Affairs Offices from which the map can be obtained are those located at New Orleans, Mobile, Vicksburg, Memphis, Nashville, Louisville, Pittsburgh, Chicago, St. Louis, Rock Island, St. Paul, Kansas City, Omaha, Tulsa, Little Rock and Galveston. ■

Aesthetics in Civil Works

The Southwestern Division of the U.S. Army Corps of Engineers and the University of Texas at Dallas recently cosponsored an "Aesthetics in Civil Works" seminar for representatives of private design firms and senior level Corps personnel.

Objective of the seminar was to increase awareness of the aesthetic possibilities in design. Emphasis was placed on the need to see and discuss good design alternatives that incorporate aesthetics as a natural and integral component.

Speakers included leading engineering, architecture and landscape architecture professionals with both practical and teaching experience. Among the presentations were discussions on the principles of good design as well as examples of completed projects exhibiting these principles. Requirements stressed by the speakers were awareness of aesthetics in the early project stages and the need to design for the particular environment associated with a given project. Also discussed was the potential cost savings realized by providing acceptable designs, because they tend to lessen the probability of project delays.

Keynote speaker Paul Spreiregen, an architect and planning consultant, used Webster to define aesthetics as "relating to or dealing with the beautiful" and then attempted to define beauty in structure with the following "old dictionary" explanations: (1) an elegant technical resolution of the problem at hand; (2) harmonious relationship of the structure and its environment; and (3) the structure should present a visible expression of its function. Although admitting to some expression of preference in designing, Spreiregen declared that most people *feel* when a design is correct or incorrect.

Suggestions have been made for additional seminars on this subject, but no plans are currently underway. ■

Award Winner

Water Spectrum received first place in the magazine category at the annual awards banquet of the Society for Technical Communication held June 9, 1976 at the National Press Club in Washington, D.C. The judging was based on relevance, quality and overall excellence. Accepting the award was Seymour Reitman, the editor.

Letters to the Editor

A Different Tree

After reading the article, "Treeing The Issues," in your Winter 1975-76 issue, which describes my graphic technique for analyzing complex issues, several people have asked me how issue trees differ from decision trees. Decision trees are a well-known device for laying out alternatives and breaking these down into subalternatives.

Issue trees differ from decision trees in that they lay out not only one's alternatives, but also all of the reasoning which is involved in evaluating alternatives. Evalu-

ation reasoning typically includes a discussion of trade-offs between alternatives, questions about sources and reliability of information, and clarifying explanations, as well as many other lines of thought. In the technical language of issue analysis, decision trees are merely a special class of issue trees, where only "how?" or "then what?" moves are allowed.

Whether to use a decision tree or an issue tree depends primarily upon the scope of the problem at hand. Decision trees are relatively simple, so they should be used when a quick layout of alternatives is desired. In fact, there are a variety of simple issue tree types, other than decision trees, which may be used. But if a full analysis of the issues, including all important lines of reasoning, is desired, the full power of an issue tree should be utilized.

David Wojick, Ph.D.
Carnegie-Mellon University
Pittsburgh, Pennsylvania

Unmitigated Steelhead

As one who has spent many a quiet and relaxing hour trying to catch the elusive steelhead in the formerly free-flowing Snake River, I could not but note that your recent article by John L. McKern, "Mitigation Can't Wait," fails to mention the total and unmitigated loss of those many miles of steelhead fishery which once were readily accessible to residents of the Pullman-Moscow area (of Washington and Idaho).

Leonard C. Johnson
State Board of Soil and Water
Conservation Districts
Madison, Wisconsin

Editor's Note: We asked author John McKern to comment on Mr. Johnson's letter. His reply follows.

The article does not mention steelhead losses or, for that matter, other fish losses in detail because it was intended to be primarily about wildlife.

Nonetheless, we share your concern about the loss of steelhead angling caused by the construction of our dams. The Federal and State Fish and Wildlife agencies in Oregon, Washington and Idaho have recommended measures to compensate for . . . losses resulting from the construction and operation of the Lower Snake Project (Ice Harbor, Lower Monumental, Little Goose and Lower Granite Dams). We have accepted essentially all of these recommendations and will proceed with the compensation when Congress authorizes us to do so.

Dealing specifically with steelhead, compensation will include the construction of hatcheries to replace losses of fish and the acquisition of access for anglers on 150 miles of undammed tributary streams to replace lost angling opportunities. While the compensation effort does not reinstate the type of angling you enjoyed where you enjoyed it, it (the compensation effort) will preserve for the people of this region the quality angling experience known as "steelheading."

In the article, I state . . . that mitigation was getting a late start. . . . this is the case with the Lower Snake Project Compensation Plan. Had compensation occurred concurrently with construction, the loss of angling, hunting and other pleasures associated with fish and wildlife would not have been so great nor would they have lasted so long.

John L. McKern
Fish and Wildlife Biologist
Walla Walla District, North Pacific Division

Coming Events

23rd National Watershed Congress National Convention at Biloxi, Miss., June 27-30.

7th World Dredging Conference at San Francisco, Calif., July 9-13.

National Waterways Conference at Louisville, Ky., September 15-17.

International Association of Game, Fish and Conservation Commissioners National Convention at Dearborn, Mich., September 22-24. ■

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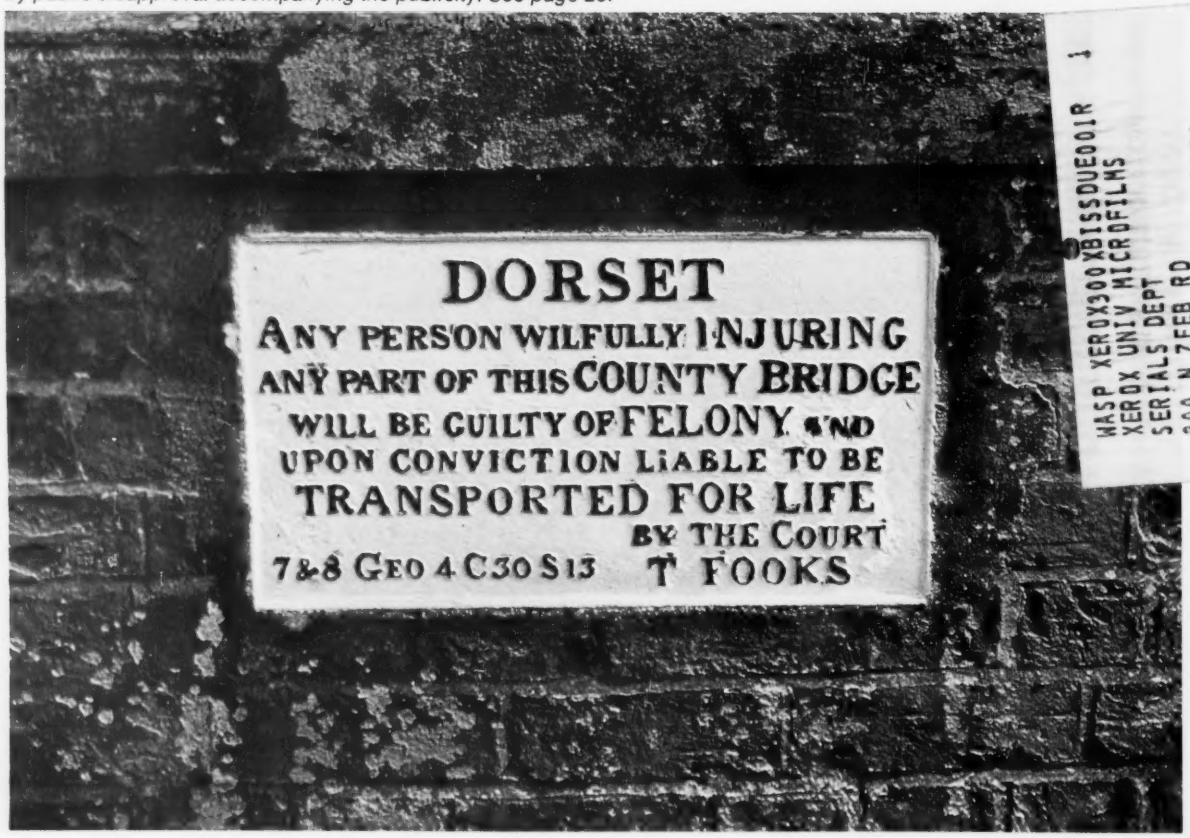
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